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# H8S/2600 Series, H8S/2000 Series

## Software Manual

### Renesas 16-Bit Single-Chip Microcomputer H8S Family

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# Preface

The H8S/2600 Series and the H8S/2000 Series are built around an H8S/2000 CPU core.

The H8S/2600 and H8S/2000 CPUs have the same internal 32-bit architecture. Both CPUs execute basic instructions in one state, have sixteen 16-bit registers, and have a concise, optimized instruction set. They can address a 16-Mbyte linear address space. Programs coded in the high-level language C can be compiled to high-speed executable code.

For easy migration, the instruction set is upward-compatible with the H8/300H, H8/300, and H8/300L Series at the object-code level.

The H8S/2600 CPU is upward-compatible with the H8S/2000 CPU at the object-code level, and supports sum of products instructions.

This manual gives details of the H8S/2600 and H8S/2000 instructions and can be used with all microcontrollers in the H8S/2600 Series and the H8S/2000 Series.

For hardware details, refer to the relevant microcontroller hardware manuals.



# Main Revisions for This Edition

| Item   | Page                           | Revisions (See Manual for Details)  |                                |                                |                          |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
|--|--------------------------------|---|--------------------------------|--------------------------------|--------------------------|--------------------------------|---------------------------|-------------------------|---|--------|---|--------|----|---|---|--------|---|--------|----|---|---|--------|---|--------|----|---|---|--------|---|--------|----|---|
| 1.1.1 Features   | 2                              | Note * added<br>— Maximum clock frequency: 20 MHz*<br><br>Note: * The maximum operating frequency and instruction execution time differ depending on the product.   |                                |                                |                          |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
| 2.2.22 CLRMAC<br>Operand Format and<br>Number of States<br>Required for Execution        | 90                             | Further explanation added to note<br><br>The number of states may differ depending on the product. For details, refer to the hardware manual of the product in question.  |                                |                                |                          |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
| 2.2.24 DAA<br>Description  | 94                             | Table amended<br><br><table border="1"> <thead> <tr> <th>C Flag before Adjustment</th> <th>Upper 4 Bits before Adjustment</th> <th>H Flag before Adjustment</th> <th>Lower 4 Bits before Adjustment</th> <th>Value Added (Hexadecimal)</th> <th>C Flag after Adjustment</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>A to F</td> <td>1</td> <td>0 to 3</td> <td>66</td> <td>1</td> </tr> <tr> <td>1</td> <td>0 to 2</td> <td>0</td> <td>0 to 9</td> <td>60</td> <td>1</td> </tr> <tr> <td>1</td> <td>0 to 2</td> <td>0</td> <td>A to F</td> <td>66</td> <td>1</td> </tr> <tr> <td>1</td> <td>0 to 3</td> <td>1</td> <td>0 to 3</td> <td>66</td> <td>1</td> </tr> </tbody> </table> | C Flag before Adjustment       | Upper 4 Bits before Adjustment | H Flag before Adjustment | Lower 4 Bits before Adjustment | Value Added (Hexadecimal) | C Flag after Adjustment | 0 | A to F | 1 | 0 to 3 | 66 | 1 | 1 | 0 to 2 | 0 | 0 to 9 | 60 | 1 | 1 | 0 to 2 | 0 | A to F | 66 | 1 | 1 | 0 to 3 | 1 | 0 to 3 | 66 | 1 |
| C Flag before Adjustment   | Upper 4 Bits before Adjustment | H Flag before Adjustment  | Lower 4 Bits before Adjustment | Value Added (Hexadecimal)      | C Flag after Adjustment  |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
| 0  | A to F                         | 1   | 0 to 3                         | 66                             | 1                        |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
| 1  | 0 to 2                         | 0   | 0 to 9                         | 60                             | 1                        |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
| 1  | 0 to 2                         | 0   | A to F                         | 66                             | 1                        |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
| 1  | 0 to 3                         | 1   | 0 to 3                         | 66                             | 1                        |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
| 2.2.37 LDMAC<br>Operand Format and<br>Number of States<br>Required for Execution         | 130                            | Further explanation added to note<br><br>The number of states may differ depending on the product. For details, refer to the hardware manual of the product in question.  |                                |                                |                          |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
| 2.2.42 (1) MULXS (B)<br>Operand Format and<br>Number of States<br>Required for Execution | 151                            |   |                                |                                |                          |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
| 2.2.42 (2) MULXS (W)<br>Operand Format and<br>Number of States<br>Required for Execution | 152                            |   |                                |                                |                          |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
| 2.2.43 (1) MULXU (B)<br>Operand Format and<br>Number of States<br>Required for Execution | 153                            |   |                                |                                |                          |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |
| 2.2.43 (2) MULXU (W)<br>Operand Format and<br>Number of States<br>Required for Execution | 154                            |   |                                |                                |                          |                                |                           |                         |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |   |        |   |        |    |   |

**Item**                      **Page**                      **Revisions (See Manual for Details)**

2.2.64 STMAC  
Operand Format and  
Number of States  
Required for Execution

232

Table amended

| Instruction Format |          |          |          |
|--------------------|----------|----------|----------|
| 1st byte           | 2nd byte | 3rd byte | 4th byte |
| 0                  | 2        | 2        | 0;erd    |
| 0                  | 2        | 3        | 0;erd    |

Further explanation added to note

The number of states may differ depending on the product. For details, refer to the hardware manual of the product in question.

2.3 Instruction Set  
Table 2.1 Instruction  
Set

250,  
251,  
260,  
262

Note 7 amended and note 10 added

| Mnemonic |                | No. of States <sup>*1</sup>                |          |
|----------|----------------|--|----------|
|          |                | Normal                                     | Advanced |
| DAS      | DAS Rd         | 1  |          |
| MULXU    | MULXU.B Rs,Rd  | 3 (12 <sup>*7</sup> )<br><sup>*4 #10</sup> |          |
|          | MULXU.W Rs,ERd | 4 (20 <sup>*7</sup> )<br><sup>*4 #10</sup> |          |
| MULXS    | MULXS.B Rs,Rd  | 4 (13 <sup>*7</sup> )<br><sup>*5 #10</sup> |          |
|          | MULXS.W Rs,ERd | 5 (21 <sup>*7</sup> )<br><sup>*5 #10</sup> |          |

| Mnemonic             |                 | No. of States <sup>*1</sup> |          |
|----------------------|-----------------|-----------------------------|----------|
|                      |                 | Normal                      | Advanced |
| MAC <sup>*9</sup>    | MAC @ERn+,@ERm+ | 4                           |          |
| CLRMAC <sup>*9</sup> | CLRMAC          | 2 <sup>*6 #10</sup>         |          |
| LDMAC <sup>*9</sup>  | LDMAC ERs,MACH  | 2 <sup>*6 #10</sup>         |          |
|                      | LDMAC ERs,MACL  | 2 <sup>*6 #10</sup>         |          |
| STMAC <sup>*9</sup>  | STMAC MACH,ERd  | 1 <sup>*6 #10</sup>         |          |
|                      | STMAC MACL,ERd  | 1 <sup>*6 #10</sup>         |          |

| Mnemonic |            | No. of States <sup>*1</sup> |                    |
|----------|------------|-----------------------------|--------------------|
|          |            | Normal                      | Advanced           |
| TRAPA    | TRAPA #x:2 | 7[9] <sup>*7</sup>          | 8[9] <sup>*7</sup> |
| RTE      | RTE        | 5[9] <sup>*7</sup>          |                    |

Notes: 7. Values in parentheses ( ) are for the H8S/2000 CPU. Values in square brackets [ ] apply to interrupt control modes 2 and 3.

10. The number of states may differ depending on the product. For details, refer to the hardware manual of the product in question.



| Item  | Page               | Revisions (See Manual for Details)   |                     |                 |                   |                     |                    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
|---|--------------------|--|---------------------|-----------------|-------------------|---------------------|--------------------|------------------|------------------|--------------------|---|---|---|---|---|---|--|----------------------|--------|---|---|--|--|--|-----------------|-------------|----------|-------------------|---------------------|-----------------|------------------|------------------|--------------------|---|---|---|---|---|---|--|---------------------|----------------|---|---|--|--|--|-----------------|--|----------------|---|---|--|--|--|-----------------|-------------|----------|-------------------|---------------------|-----------------|------------------|------------------|--------------------|---|---|---|---|---|---|--|-------|---------------|----------|---|---|--|--|-----------------|--|--|----------|---|---|--|--|---|--|----------------|----------|---|---|--|--|-----------------|--|--|----------|---|---|--|--|---|-------|---------------|----------|---|---|--|--|-----------------|--|--|----------|---|---|--|--|---|--|----------------|----------|---|---|--|--|-----------------|--|--|----------|---|---|--|--|---|-------------|----------|-------------------|---------------------|-----------------|------------------|------------------|--------------------|---|---|---|---|---|---|--|---------------------|----------------|---|--|--|--|--|-----------------|--|----------------|---|--|--|--|--|-----------------|
| 2.6 Number of States Required for Instruction Execution | 283, 285, 286, 288 | Note 6 added   |                     |                 |                   |                     |                    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| Table 2.5 Number of Cycles in Instruction Execution     |                    | <table border="1"> <thead> <tr> <th>Instruction</th> <th>Mnemonic</th> <th>Instruction Fetch</th> <th>Branch Address Read</th> <th>Stack Operation</th> <th>Byte Data Access</th> <th>Word Data Access</th> <th>Internal Operation</th> </tr> <tr> <th>I</th> <th>J</th> <th>K</th> <th>L</th> <th>M</th> <th>N</th> <th></th> </tr> </thead> <tbody> <tr> <td>CLRMAC<sup>25</sup></td> <td>CLRMAC</td> <td>1</td> <td>1</td> <td></td> <td></td> <td></td> <td>0<sup>25</sup></td> </tr> </tbody> </table><br><table border="1"> <thead> <tr> <th>Instruction</th> <th>Mnemonic</th> <th>Instruction Fetch</th> <th>Branch Address Read</th> <th>Stack Operation</th> <th>Byte Data Access</th> <th>Word Data Access</th> <th>Internal Operation</th> </tr> <tr> <th>I</th> <th>J</th> <th>K</th> <th>L</th> <th>M</th> <th>N</th> <th></th> </tr> </thead> <tbody> <tr> <td>LDMAC<sup>25</sup></td> <td>LDMAC ERs,MACH</td> <td>1</td> <td>1</td> <td></td> <td></td> <td></td> <td>0<sup>25</sup></td> </tr> <tr> <td></td> <td>LDMAC ERs,MACL</td> <td>1</td> <td>1</td> <td></td> <td></td> <td></td> <td>0<sup>25</sup></td> </tr> </tbody> </table><br><table border="1"> <thead> <tr> <th>Instruction</th> <th>Mnemonic</th> <th>Instruction Fetch</th> <th>Branch Address Read</th> <th>Stack Operation</th> <th>Byte Data Access</th> <th>Word Data Access</th> <th>Internal Operation</th> </tr> <tr> <th>I</th> <th>J</th> <th>K</th> <th>L</th> <th>M</th> <th>N</th> <th></th> </tr> </thead> <tbody> <tr> <td>MULXS</td> <td>MULXS.B Rs,Rd</td> <td>H8S/2600</td> <td>2</td> <td>2</td> <td></td> <td></td> <td>0<sup>25</sup></td> </tr> <tr> <td></td> <td></td> <td>H8S/2000</td> <td>2</td> <td>1</td> <td></td> <td></td> <td>1</td> </tr> <tr> <td></td> <td>MULXS.W Rs,ERd</td> <td>H8S/2600</td> <td>2</td> <td>3</td> <td></td> <td></td> <td>0<sup>25</sup></td> </tr> <tr> <td></td> <td></td> <td>H8S/2000</td> <td>2</td> <td>1</td> <td></td> <td></td> <td>9</td> </tr> <tr> <td>MULXU</td> <td>MULXU.B Rs,Rd</td> <td>H8S/2600</td> <td>1</td> <td>2</td> <td></td> <td></td> <td>0<sup>25</sup></td> </tr> <tr> <td></td> <td></td> <td>H8S/2000</td> <td>1</td> <td>1</td> <td></td> <td></td> <td>1</td> </tr> <tr> <td></td> <td>MULXU.W Rs,ERd</td> <td>H8S/2600</td> <td>1</td> <td>3</td> <td></td> <td></td> <td>0<sup>25</sup></td> </tr> <tr> <td></td> <td></td> <td>H8S/2000</td> <td>1</td> <td>1</td> <td></td> <td></td> <td>9</td> </tr> </tbody> </table><br><table border="1"> <thead> <tr> <th>Instruction</th> <th>Mnemonic</th> <th>Instruction Fetch</th> <th>Branch Address Read</th> <th>Stack Operation</th> <th>Byte Data Access</th> <th>Word Data Access</th> <th>Internal Operation</th> </tr> <tr> <th>I</th> <th>J</th> <th>K</th> <th>L</th> <th>M</th> <th>N</th> <th></th> </tr> </thead> <tbody> <tr> <td>STMAC<sup>25</sup></td> <td>STMAC MACH,ERd</td> <td>1</td> <td></td> <td></td> <td></td> <td></td> <td>0<sup>25</sup></td> </tr> <tr> <td></td> <td>STMAC MACL,ERd</td> <td>1</td> <td></td> <td></td> <td></td> <td></td> <td>0<sup>25</sup></td> </tr> </tbody> </table> | Instruction         | Mnemonic        | Instruction Fetch | Branch Address Read | Stack Operation    | Byte Data Access | Word Data Access | Internal Operation | I | J | K | L | M | N |  | CLRMAC <sup>25</sup> | CLRMAC | 1 | 1 |  |  |  | 0 <sup>25</sup> | Instruction | Mnemonic | Instruction Fetch | Branch Address Read | Stack Operation | Byte Data Access | Word Data Access | Internal Operation | I | J | K | L | M | N |  | LDMAC <sup>25</sup> | LDMAC ERs,MACH | 1 | 1 |  |  |  | 0 <sup>25</sup> |  | LDMAC ERs,MACL | 1 | 1 |  |  |  | 0 <sup>25</sup> | Instruction | Mnemonic | Instruction Fetch | Branch Address Read | Stack Operation | Byte Data Access | Word Data Access | Internal Operation | I | J | K | L | M | N |  | MULXS | MULXS.B Rs,Rd | H8S/2600 | 2 | 2 |  |  | 0 <sup>25</sup> |  |  | H8S/2000 | 2 | 1 |  |  | 1 |  | MULXS.W Rs,ERd | H8S/2600 | 2 | 3 |  |  | 0 <sup>25</sup> |  |  | H8S/2000 | 2 | 1 |  |  | 9 | MULXU | MULXU.B Rs,Rd | H8S/2600 | 1 | 2 |  |  | 0 <sup>25</sup> |  |  | H8S/2000 | 1 | 1 |  |  | 1 |  | MULXU.W Rs,ERd | H8S/2600 | 1 | 3 |  |  | 0 <sup>25</sup> |  |  | H8S/2000 | 1 | 1 |  |  | 9 | Instruction | Mnemonic | Instruction Fetch | Branch Address Read | Stack Operation | Byte Data Access | Word Data Access | Internal Operation | I | J | K | L | M | N |  | STMAC <sup>25</sup> | STMAC MACH,ERd | 1 |  |  |  |  | 0 <sup>25</sup> |  | STMAC MACL,ERd | 1 |  |  |  |  | 0 <sup>25</sup> |
| Instruction   | Mnemonic           | Instruction Fetch  | Branch Address Read | Stack Operation | Byte Data Access  | Word Data Access    | Internal Operation |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| I   | J                  | K  | L                   | M               | N                 |                     |                    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| CLRMAC <sup>25</sup>                                    | CLRMAC             | 1  | 1                   |                 |                   |                     | 0 <sup>25</sup>    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| Instruction   | Mnemonic           | Instruction Fetch  | Branch Address Read | Stack Operation | Byte Data Access  | Word Data Access    | Internal Operation |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| I   | J                  | K  | L                   | M               | N                 |                     |                    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| LDMAC <sup>25</sup>                                     | LDMAC ERs,MACH     | 1  | 1                   |                 |                   |                     | 0 <sup>25</sup>    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
|   | LDMAC ERs,MACL     | 1  | 1                   |                 |                   |                     | 0 <sup>25</sup>    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| Instruction   | Mnemonic           | Instruction Fetch  | Branch Address Read | Stack Operation | Byte Data Access  | Word Data Access    | Internal Operation |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| I   | J                  | K  | L                   | M               | N                 |                     |                    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| MULXS   | MULXS.B Rs,Rd      | H8S/2600   | 2                   | 2               |                   |                     | 0 <sup>25</sup>    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
|   |                    | H8S/2000   | 2                   | 1               |                   |                     | 1                  |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
|   | MULXS.W Rs,ERd     | H8S/2600   | 2                   | 3               |                   |                     | 0 <sup>25</sup>    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
|   |                    | H8S/2000   | 2                   | 1               |                   |                     | 9                  |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| MULXU   | MULXU.B Rs,Rd      | H8S/2600   | 1                   | 2               |                   |                     | 0 <sup>25</sup>    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
|   |                    | H8S/2000   | 1                   | 1               |                   |                     | 1                  |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
|   | MULXU.W Rs,ERd     | H8S/2600   | 1                   | 3               |                   |                     | 0 <sup>25</sup>    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
|   |                    | H8S/2000   | 1                   | 1               |                   |                     | 9                  |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| Instruction   | Mnemonic           | Instruction Fetch  | Branch Address Read | Stack Operation | Byte Data Access  | Word Data Access    | Internal Operation |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| I   | J                  | K  | L                   | M               | N                 |                     |                    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| STMAC <sup>25</sup>                                     | STMAC MACH,ERd     | 1  |                     |                 |                   |                     | 0 <sup>25</sup>    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
|   | STMAC MACL,ERd     | 1  |                     |                 |                   |                     | 0 <sup>25</sup>    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| 2.7 Bus States During Instruction Execution             | 290                | :M deleted from legend   |                     |                 |                   |                     |                    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| Table 2.6 Instruction Execution Cycles                  | 293 to 302         | All instances of :M deleted from table   |                     |                 |                   |                     |                    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |
| 3.3.5 Usage Notes                                       | 312, 313           | Newly added  |                     |                 |                   |                     |                    |                  |                  |                    |   |   |   |   |   |   |  |                      |        |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |   |  |  |  |                 |  |                |   |   |  |  |  |                 |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |       |               |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |  |                |          |   |   |  |  |                 |  |  |          |   |   |  |  |   |             |          |                   |                     |                 |                  |                  |                    |   |   |   |   |   |   |  |                     |                |   |  |  |  |  |                 |  |                |   |  |  |  |  |                 |

Notes: 6. The number of states may differ depending on the product. For details, refer to the hardware manual of the product in question.



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# Section 1 CPU

## 1.1 Overview

The H8S/2600 CPU and the H8S/2000 CPU are high-speed central processing units with a common an internal 32-bit architecture. Each CPU is upward-compatible with the H8/300 and H8/300H CPUs. The H8S/2600 CPU and H8S/2000 CPU have sixteen 16-bit general registers, can address a 4-Gbyte linear address space, and are ideal for realtime control.

### 1.1.1 Features

The H8S/2600 CPU and H8S/2000 CPU have the following features.

- Upward-compatible with H8/300 and H8/300H CPUs
  - Can execute H8/300 and H8/300H object programs
- General-register architecture
  - Sixteen 16-bit general registers (also usable as sixteen 8-bit registers or eight 32-bit registers)
- Sixty-nine basic instructions (H8S/2000 CPU has sixty-five)
  - 8/16/32-bit arithmetic and logic instructions
  - Multiply and divide instructions
  - Powerful bit-manipulation instructions
  - Multiply-and-accumulate instruction (H8S/2600 CPU only)
- Eight addressing modes
  - Register direct [Rn]
  - Register indirect [@ERn]
  - Register indirect with displacement [@(d:16,ERn) or @(d:32,ERn)]
  - Register indirect with post-increment or pre-decrement [@ERn+ or @-ERn]
  - Absolute address [@aa:8, @aa:16, @aa:24, or @aa:32]
  - Immediate [#xx:8, #xx:16, or #xx:32]
  - Program-counter relative [@(d:8,PC) or @(d:16,PC)]
  - Memory indirect [@@aa:8]
- 4-Gbyte address space
  - Program: 16 Mbytes
  - Data: 4 Gbytes

- High-speed operation
  - All frequently-used instructions execute in one or two states
  - Maximum clock frequency: 20 MHz\*
  - 8/16/32-bit register-register add/subtract: 50 ns
  - $8 \times 8$ -bit register-register multiply: 150 ns (H8S/2000 CPU: 600 ns)
  - $16 \div 8$ -bit register-register divide: 600 ns
  - $16 \times 16$ -bit register-register multiply: 200 ns (H8S/2000 CPU: 1000 ns)
  - $32 \div 16$ -bit register-register divide: 1000 ns
- Two CPU operating modes
  - Normal mode
  - Advanced mode
- Power-down modes
  - Transition to power-down state by SLEEP instruction
  - CPU clock speed selection

Note: \* The maximum operating frequency and instruction execution time differ depending on the product.

### 1.1.2 Differences between H8S/2600 CPU and H8S/2000 CPU

Differences between the H8S/2600 CPU and the H8S/2000 CPU are as follows.

- Register configuration
  - The MAC register is supported only by the H8S/2600 CPU.  
For details, see section 1.4, Register Configuration.
- Basic instructions
  - The MAC, CLRMAC, LDMAC, and STMAC instructions are supported only by the H8S/2600 CPU.  
For details, see section 1.6, Instruction Set, and Section 2, Instruction Descriptions.
- Number of states required for execution
  - The number of states required for execution of the MULXU and MULXS instructions.  
For details, see section 2.6, Number of States Required for Execution.

In addition, there may be differences in address spaces, EXR register functions, power-down states, and so on. For details, refer to the relevant microcontroller hardware manual.

### 1.1.3 Differences from H8/300 CPU

In comparison with the H8/300 CPU, the H8S/2600 CPU and H8S/2000 CPU have the following enhancements.

- More general registers and control registers
  - Eight 16-bit registers, one 8-bit and two 32-bit control registers have been added.
- Expanded address space
  - Normal mode supports the same 64-kbyte address space as the H8/300 CPU.
  - Advanced mode supports a maximum 4-Gbyte address space.
- Enhanced addressing
  - The addressing modes have been enhanced to make effective use of the 4-Gbyte address space.
- Enhanced instructions
  - Addressing modes of bit-manipulation instructions have been enhanced.
  - Signed multiply and divide instructions have been added.
  - A multiply-and-accumulate instruction has been added. (H8S/2600CPU only)
  - Two-bit shift and rotate instructions have been added.
  - Instructions for saving and restoring multiple registers have been added.
  - A test and set instruction has been added.
- Higher speed
  - Basic instructions execute twice as fast.

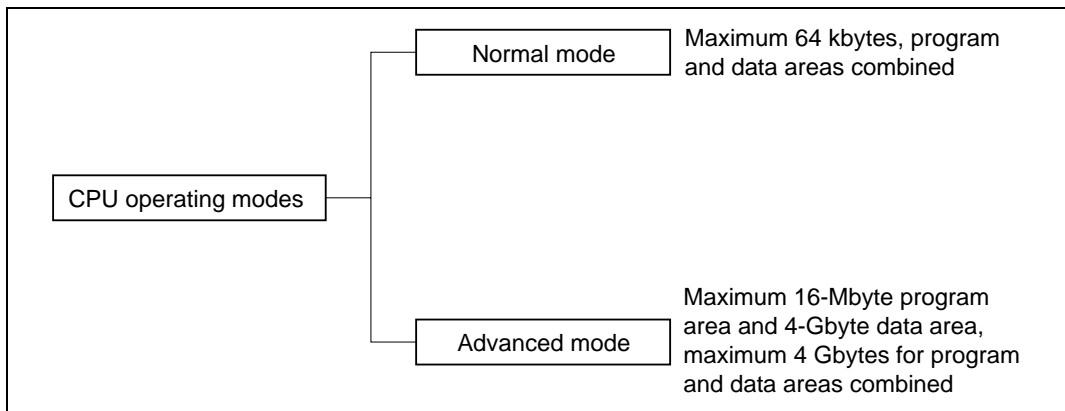
### 1.1.4 Differences from H8/300H CPU

In comparison with the H8/300H CPU, the H8S/2600 CPU and H8S/2000 CPU have the following enhancements.

- Additional control register
  - One 8-bit and two 32-bit control registers have been added.
- Expanded address space
  - Advanced mode supports a maximum 4-Gbyte data address space.
- Enhanced instructions
  - Addressing modes of bit-manipulation instructions have been enhanced.
  - A multiply-and-accumulate instruction has been added (H8S/2600 CPU only).
  - Two-bit shift and rotate instructions have been added.
  - Instructions for saving and restoring multiple registers have been added.
  - A test and set instruction has been added.
- Higher speed
  - Basic instructions execute twice as fast.

## 1.2 CPU Operating Modes

Like the H8/300H CPU, the H8S/2600 CPU has two operating modes: normal and advanced. Normal mode supports a maximum 64-kbyte address space. Advanced mode supports a maximum 4-Gbyte total address space, of which up to 16 Mbytes can be used for program code and up to 4 Gbytes for data. The mode is selected with the mode pins of the microcontroller. For further information, refer to the relevant microcontroller hardware manual.



**Figure 1.1 CPU Operating Modes**

### (1) Normal Mode

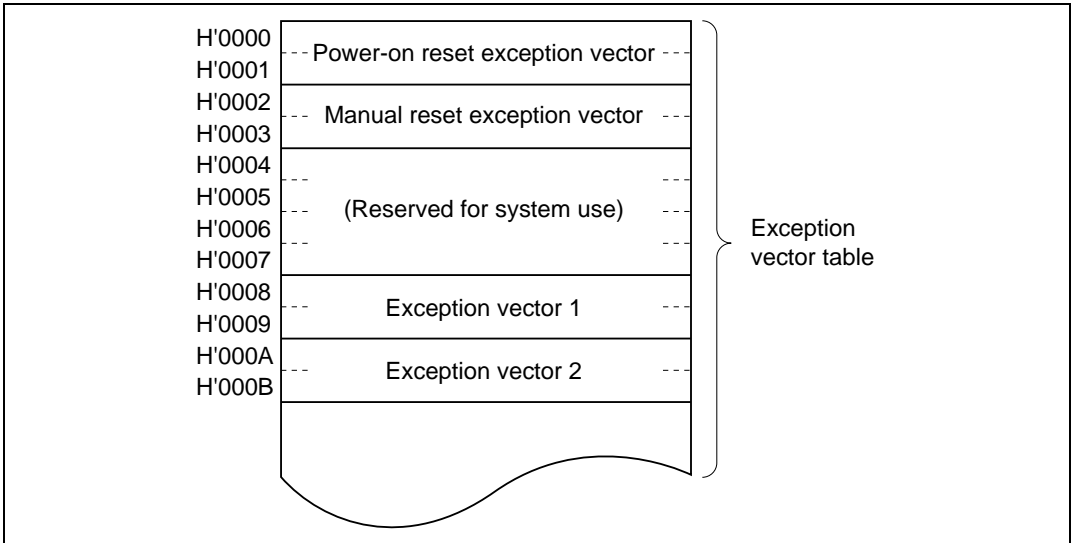
The exception vector table and stack have the same structure as in the H8/300 CPU.

**Address Space:** A maximum address space of 64 kbytes can be accessed, as in the H8/300 CPU.

**Extended Registers (En):** The extended registers (E0 to E7) can be used as 16-bit registers, or as the upper 16-bit segments of 32-bit registers. When En is used as a 16-bit register it can contain any value, even when the corresponding general register (R0 to R7) is used as an address register. If the general register is referenced in the register indirect addressing mode with pre-decrement (@-Rn) or post-increment (@Rn+) and a carry or borrow occurs, however, the value in the corresponding extended register will be affected.

**Instruction Set:** All additional instructions and addressing modes not found in the H8/300 CPU can be used. Only the lower 16 bits of effective addresses (EA) are valid.

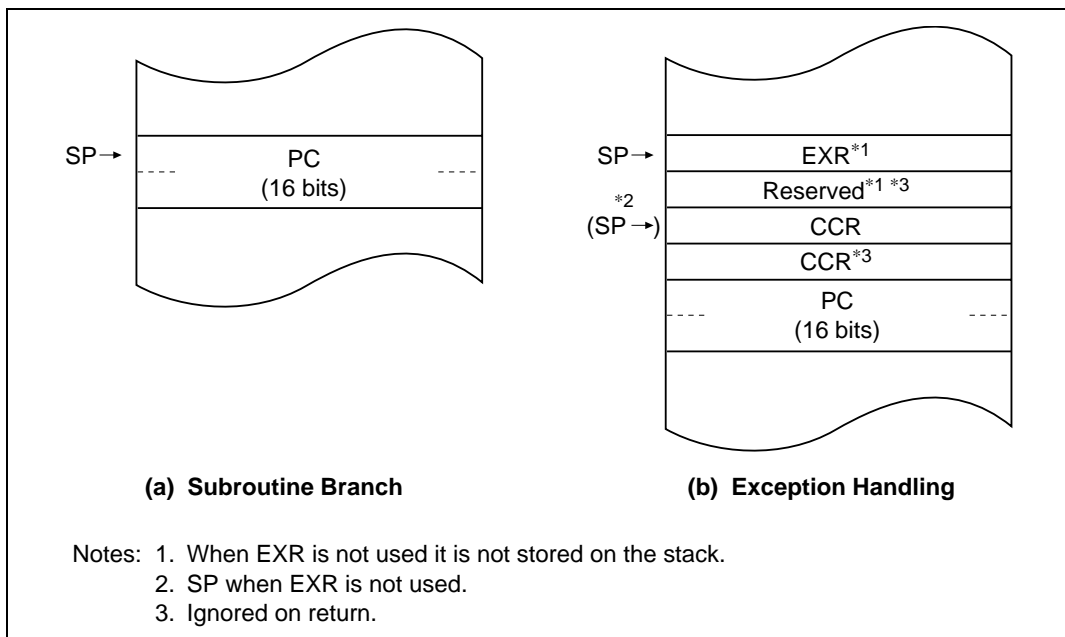
**Exception Vector Table and Memory Indirect Branch Addresses:** In normal mode the top area starting at H'0000 is allocated to the exception vector table. One branch address is stored per 16 bits (figure 1.2). The exception vector table differs depending on the microcontroller. Refer to the relevant microcontroller hardware manual for further information.



**Figure 1.2 Exception Vector Table (Normal Mode)**

The memory indirect addressing mode (@@aa:8) employed in the JMP and JSR instructions uses an 8-bit absolute address included in the instruction code to specify a memory operand that contains a branch address. In normal mode the operand is a 16-bit word operand, providing a 16-bit branch address. Branch addresses can be stored in the top area from H'0000 to H'00FF. Note that this area is also used for the exception vector table.

**Stack Structure:** When the program counter (PC) is pushed onto the stack in a subroutine call, and the PC, condition-code register (CCR), and extended control register (EXR) are pushed onto the stack in exception handling, they are stored as shown in figure 1.3. When EXR is invalid, it is not pushed onto the stack. For details, see the relevant hardware manual.



**Figure 1.3 Stack Structure in Normal Mode**

## (2) Advanced Mode

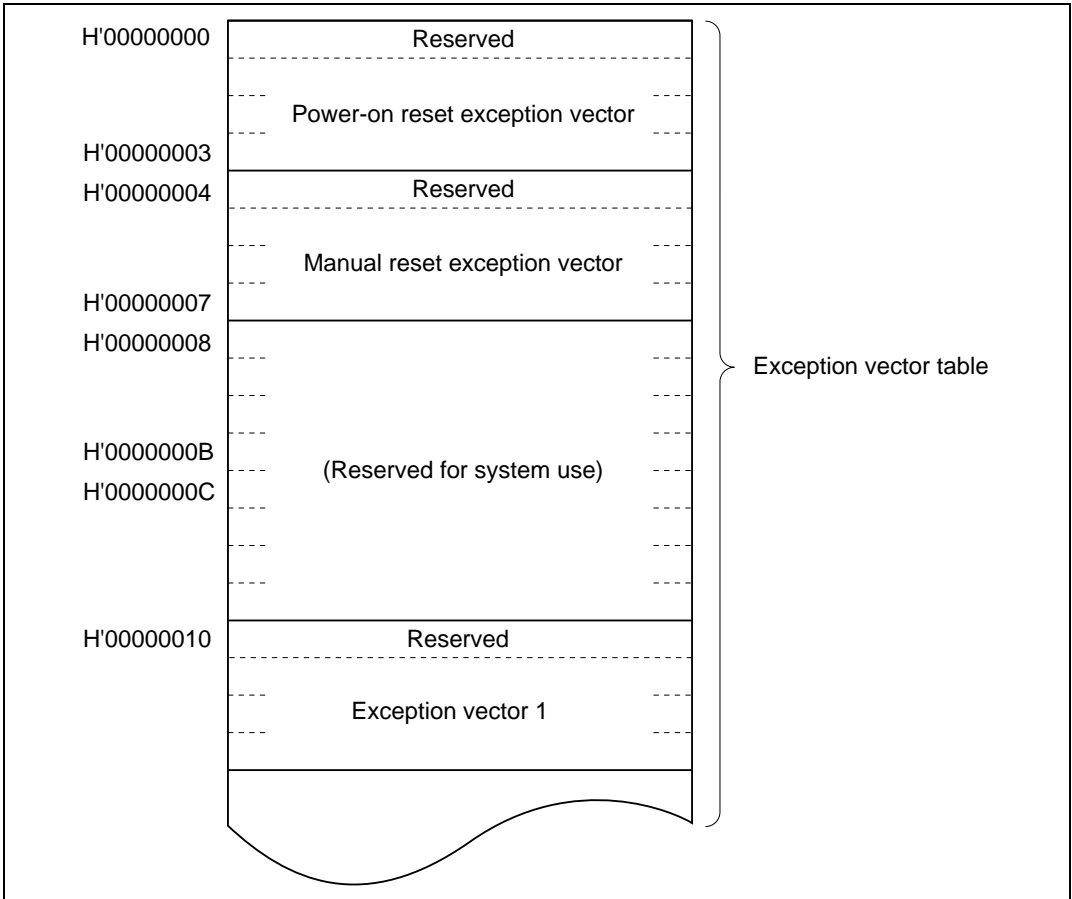
In advanced mode the data address space is larger than for the H8/300H CPU.

**Address Space:** The 4-Gbyte maximum address space provides linear access to a maximum 16 Mbytes of program code and maximum 4 Gbytes of data.

**Extended Registers (En):** The extended registers (E0 to E7) can be used as 16-bit registers, or as the upper 16-bit segments of 32-bit registers or address registers.

**Instruction Set:** All instructions and addressing modes can be used.

**Exception Vector Table and Memory Indirect Branch Addresses:** In advanced mode the top area starting at H'00000000 is allocated to the exception vector table in units of 32 bits. In each 32 bits, the upper 8 bits are ignored and a branch address is stored in the lower 24 bits (figure 1.4). The exception vector table differs depending on the microcontroller. Refer to the relevant microcontroller hardware manual for further information.

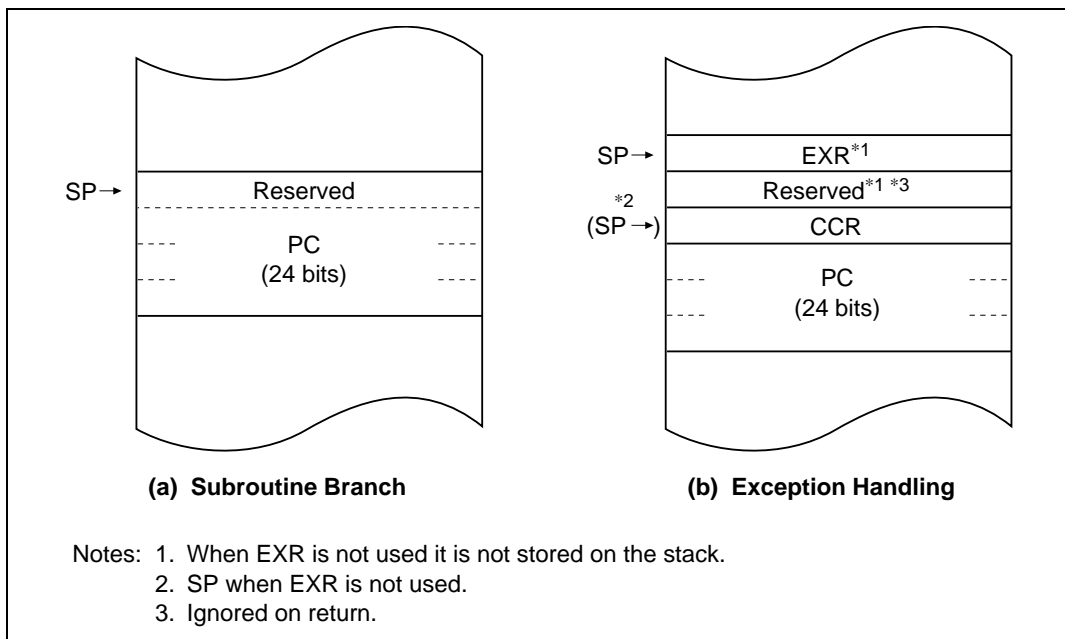


**Figure 1.4 Exception Vector Table (Advanced Mode)**

The memory indirect addressing mode (@@aa:8) employed in the JMP and JSR instructions uses an 8-bit absolute address included in the instruction code to specify a memory operand that contains a branch address. In advanced mode the operand is a 32-bit longword operand, providing a 32-bit branch address. The upper 8 bits of these 32 bits are a reserved area that is regarded as H'00. Branch addresses can be stored in the top area from H'00000000 to H'000000FF. Note that this area is also used for the exception vector table.



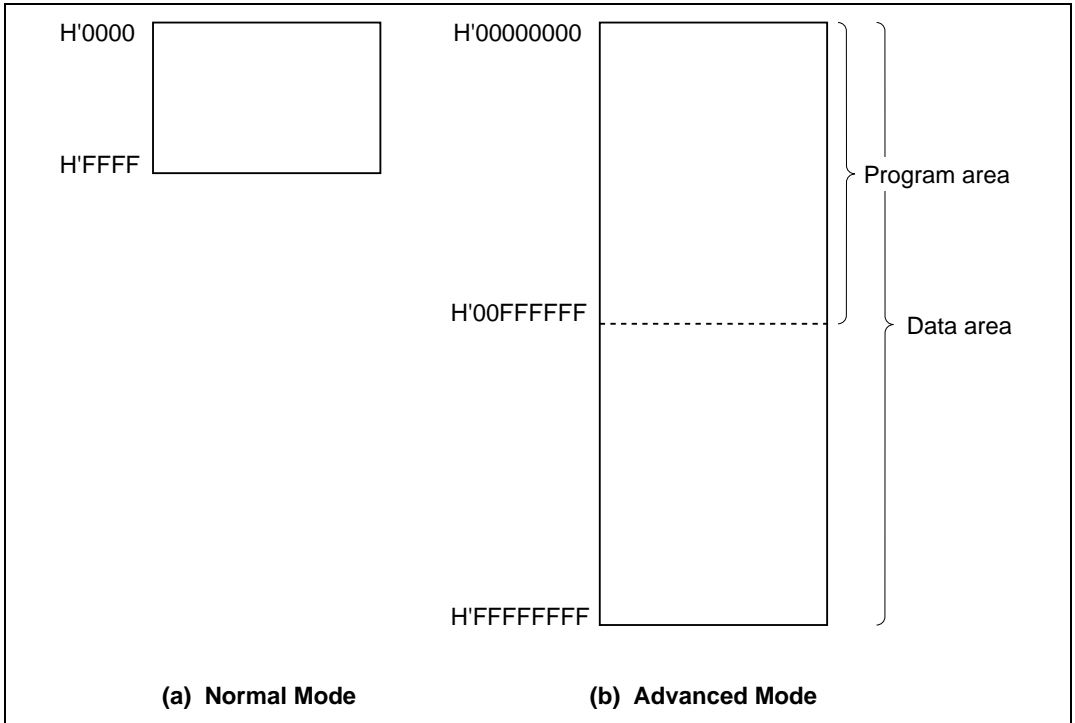
**Stack Structure:** In advanced mode, when the program counter (PC) is pushed onto the stack in a subroutine call, and the PC, condition-code register (CCR), and extended control register (EXR) are pushed onto the stack in exception handling, they are stored as shown in figure 1.5. When EXR is invalid, it is not pushed onto the stack. For details, see the relevant hardware manual.



**Figure 1.5 Stack Structure in Advanced Mode**

### 1.3 Address Space

Figure 1.6 shows a memory map of the H8S/2600 CPU. The H8S/2600 CPU provides linear access to a maximum 64-kbyte address space in normal mode, and a maximum 4-Gbyte address space in advanced mode. The address space differs depending on the operating mode. For details, refer to the relevant microcontroller hardware manual.



**Figure 1.6 Memory Map**

## 1.4 Register Configuration

### 1.4.1 Overview

The CPUs have the internal registers shown in figure 1.7. There are two types of registers: general registers and control registers. The H8S/2000 CPU does not support the MAC register.

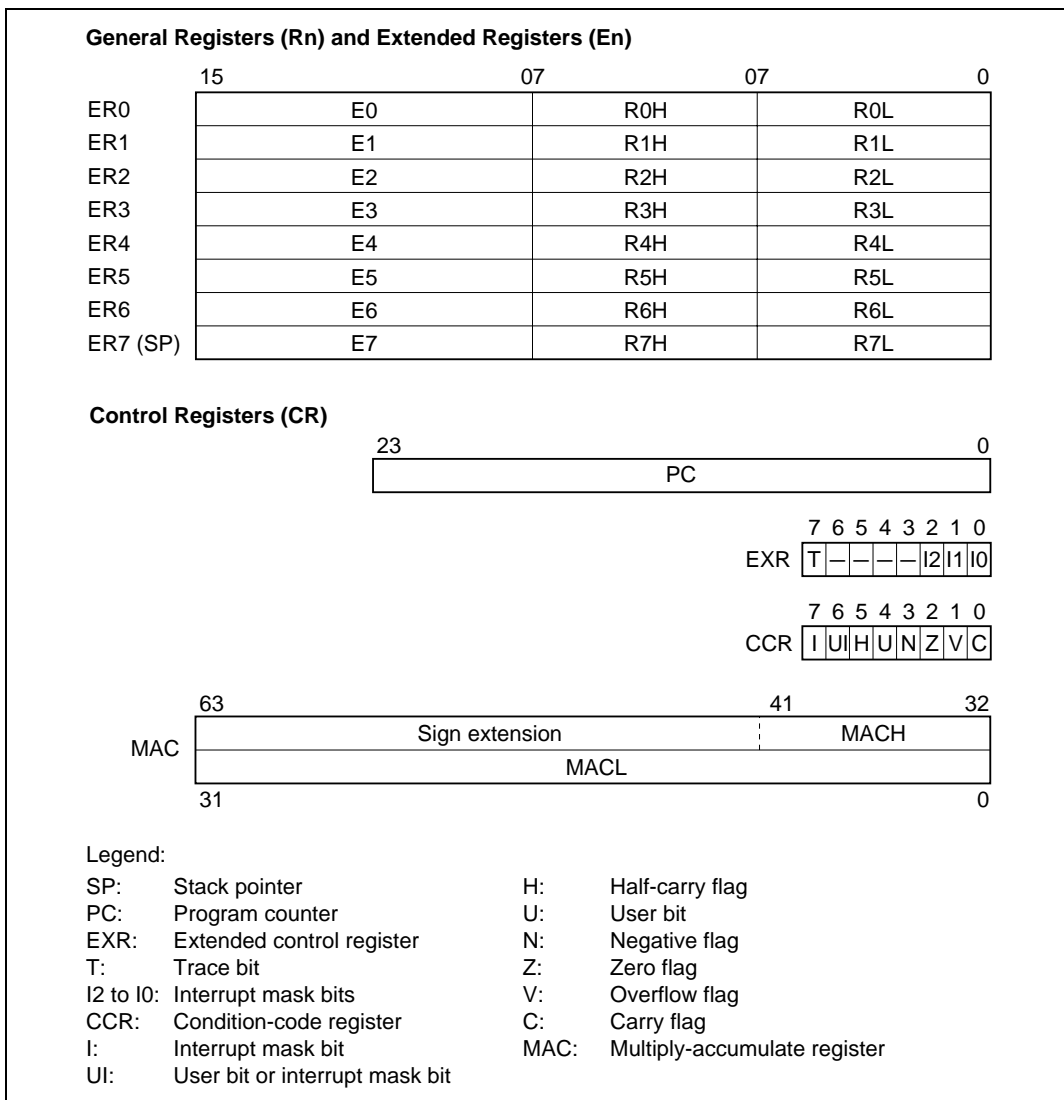


Figure 1.7 CPU Registers

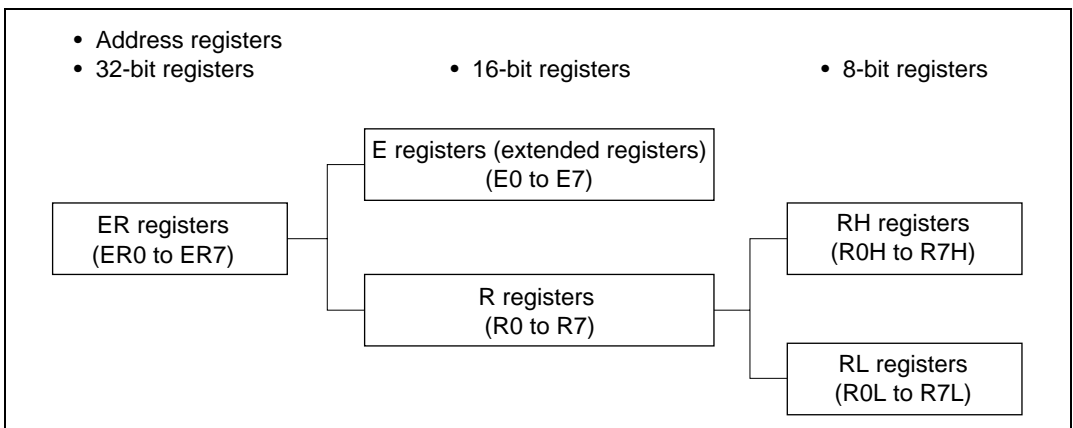
## 1.4.2 General Registers

The CPUs have eight 32-bit general registers. These general registers are all functionally alike and can be used as both address registers and data registers. When a general register is used as a data register, it can be accessed as a 32-bit, 16-bit, or 8-bit register. When the general registers are used as 32-bit registers or address registers, they are designated by the letters ER (ER0 to ER7).

The ER registers divide into 16-bit general registers designated by the letters E (E0 to E7) and R (R0 to R7). These registers are functionally equivalent, providing a maximum sixteen 16-bit registers. The E registers (E0 to E7) are also referred to as extended registers.

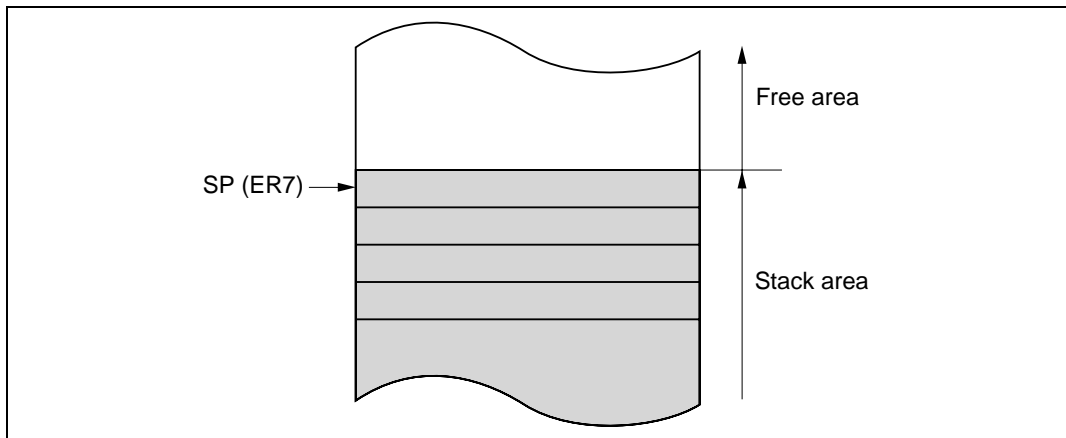
The R registers divide into 8-bit general registers designated by the letters RH (R0H to R7H) and RL (R0L to R7L). These registers are functionally equivalent, providing a maximum sixteen 8-bit registers.

Figure 1.8 illustrates the usage of the general registers. The usage of each register can be selected independently.



**Figure 1.8 Usage of General Registers**

General register ER7 has the function of stack pointer (SP) in addition to its general-register function, and is used implicitly in exception handling and subroutine calls. Figure 1.9 shows the stack.



**Figure 1.9 Stack**

### 1.4.3 Control Registers

The control registers are the 24-bit program counter (PC), 8-bit extended control register (EXR), 8-bit condition-code register (CCR), and 64-bit multiply-accumulate register (MAC: H8S/2600 CPU only).

#### (1) Program Counter (PC)

This 24-bit counter indicates the address of the next instruction the CPU will execute. The length of all CPU instructions is 16 bits (one word) or a multiple of 16 bits, so the least significant PC bit is ignored. When an instruction is fetched, the least significant PC bit is regarded as 0.

#### (2) Extended Control Register (EXR)

This 8-bit register contains the trace bit (T) and three interrupt mask bits (I2 to I0).

**Bit 7—Trace Bit (T):** Selects trace mode. When this bit is cleared to 0, instructions are executed in sequence. When this bit is set to 1, a trace exception is generated each time an instruction is executed.

**Bits 6 to 3—Reserved:** These bits are reserved, always read as 1.

**Bits 2 to 0—Interrupt Mask Bits (I2 to I0):** These bits designate the interrupt mask level (0 to 7). For details refer to the relevant microcontroller hardware manual.

Operations can be performed on the EXR bits by the LDC, STC, ANDC, ORC, and XORC instructions. All interrupts, including NMI, are disabled for three states after one of these instructions is executed, except for STC.

### (3) Condition-Code Register (CCR)

This 8-bit register contains internal CPU status information, including an interrupt mask bit (I) and half-carry (H), negative (N), zero (Z), overflow (V), and carry (C) flags.

**Bit 7—Interrupt Mask Bit (I):** Masks interrupts other than NMI when set to 1. (NMI is accepted regardless of the I bit setting.) The I bit is set to 1 by hardware at the start of an exception-handling sequence.

**Bit 6—User Bit or Interrupt Mask Bit (UI):** Can be written and read by software using the LDC, STC, ANDC, ORC, and XORC instructions. This bit can also be used as an interrupt mask bit. For details refer to the relevant microcontroller hardware manual.

**Bit 5—Half-Carry Flag (H):** When the ADD.B, ADDX.B, SUB.B, SUBX.B, CMP.B, or NEG.B instruction is executed, this flag is set to 1 if there is a carry or borrow at bit 3, and cleared to 0 otherwise. When the ADD.W, SUB.W, CMP.W, or NEG.W instruction is executed, the H flag is set to 1 if there is a carry or borrow at bit 11, and cleared to 0 otherwise. When the ADD.L, SUB.L, CMP.L, or NEG.L instruction is executed, the H flag is set to 1 if there is a carry or borrow at bit 27, and cleared to 0 otherwise.

**Bit 4—User Bit (U):** Can be written and read by software using the LDC, STC, ANDC, ORC, and XORC instructions.

**Bit 3—Negative Flag (N):** Stores the value of the most significant bit (sign bit) of data.

**Bit 2—Zero Flag (Z):** Set to 1 to indicate zero data, and cleared to 0 to indicate non-zero data.

**Bit 1—Overflow Flag (V):** Set to 1 when an arithmetic overflow occurs, and cleared to 0 at other times.

**Bit 0—Carry Flag (C):** Set to 1 when a carry occurs, and cleared to 0 otherwise. Used by:

- Add instructions, to indicate a carry
- Subtract instructions, to indicate a borrow
- Shift and rotate instructions, to store the value shifted out of the end bit

The carry flag is also used as a bit accumulator by bit manipulation instructions.

---

Some instructions leave some or all of the flag bits unchanged. For the action of each instruction on the flag bits, refer to the detailed descriptions of the instructions starting in section 2.2.1.

Operations can be performed on the CCR bits by the LDC, STC, ANDC, ORC, and XORC instructions. The N, Z, V, and C flags are used as branching conditions for conditional branch (Bcc) instructions.

#### **(4) Multiply-Accumulate Register (MAC)**

The MAC register is supported only by the H8S/2600 CPU. This 64-bit register stores the results of multiply-and-accumulate operations. It consists of two 32-bit registers denoted MACH and MACL. The lower 10 bits of MACH are valid; the upper bits are a sign extension.

#### **1.4.4 Initial Register Values**

Reset exception handling loads the CPU's program counter (PC) from the vector table, clears the trace bit in EXR to 0, and sets the interrupt mask bits in CCR and EXR to 1. The other CCR bits and the general registers are not initialized. In particular, the stack pointer (ER7) is not initialized. The stack pointer should therefore be initialized by an MOV.L instruction executed immediately after a reset.

## 1.5 Data Formats

The CPUs can process 1-bit, 4-bit (BCD), 8-bit (byte), 16-bit (word), and 32-bit (longword) data. Bit-manipulation instructions operate on 1-bit data by accessing bit  $n$  ( $n = 0, 1, 2, \dots, 7$ ) of byte operand data. The DAA and DAS decimal-adjust instructions treat byte data as two digits of 4-bit BCD data.

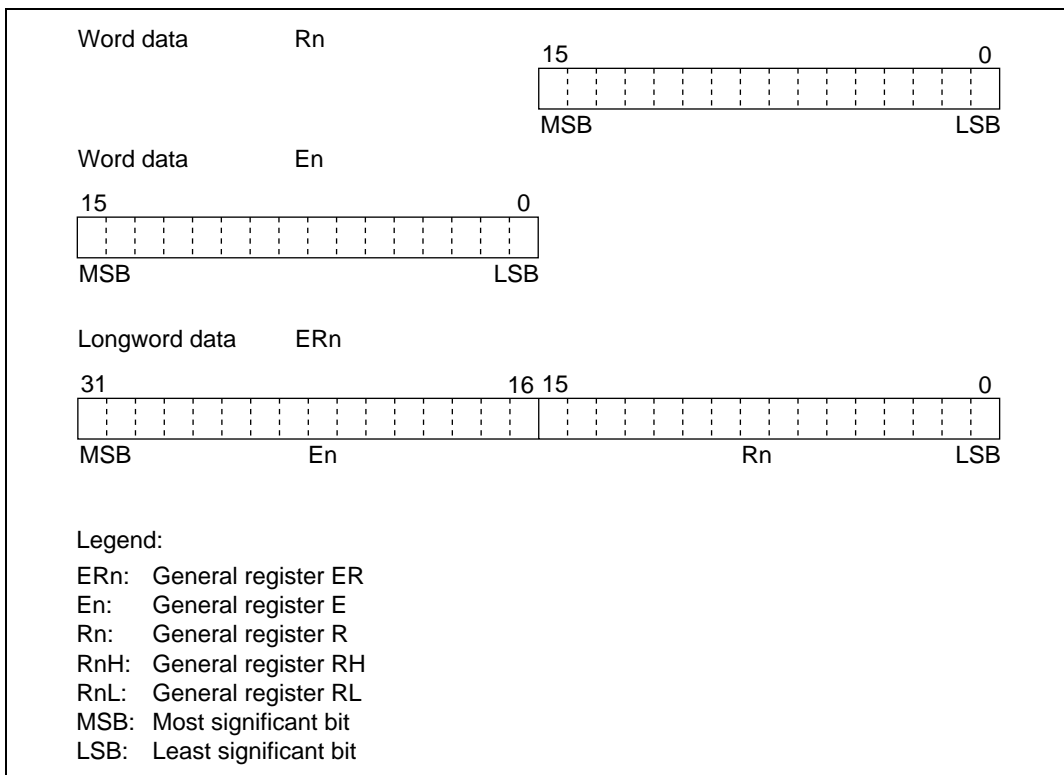
### 1.5.1 General Register Data Formats

Figure 1.10 shows the data formats in general registers.

| Data Type      | Register Number | Data Format |
|----------------|-----------------|-------------|
| 1-bit data     | RnH             |             |
| 1-bit data     | RnL             |             |
| 4-bit BCD data | RnH             |             |
| 4-bit BCD data | RnL             |             |
| Byte data      | RnH             |             |
| Byte data      | RnL             |             |

Figure 1.10 General Register Data Formats

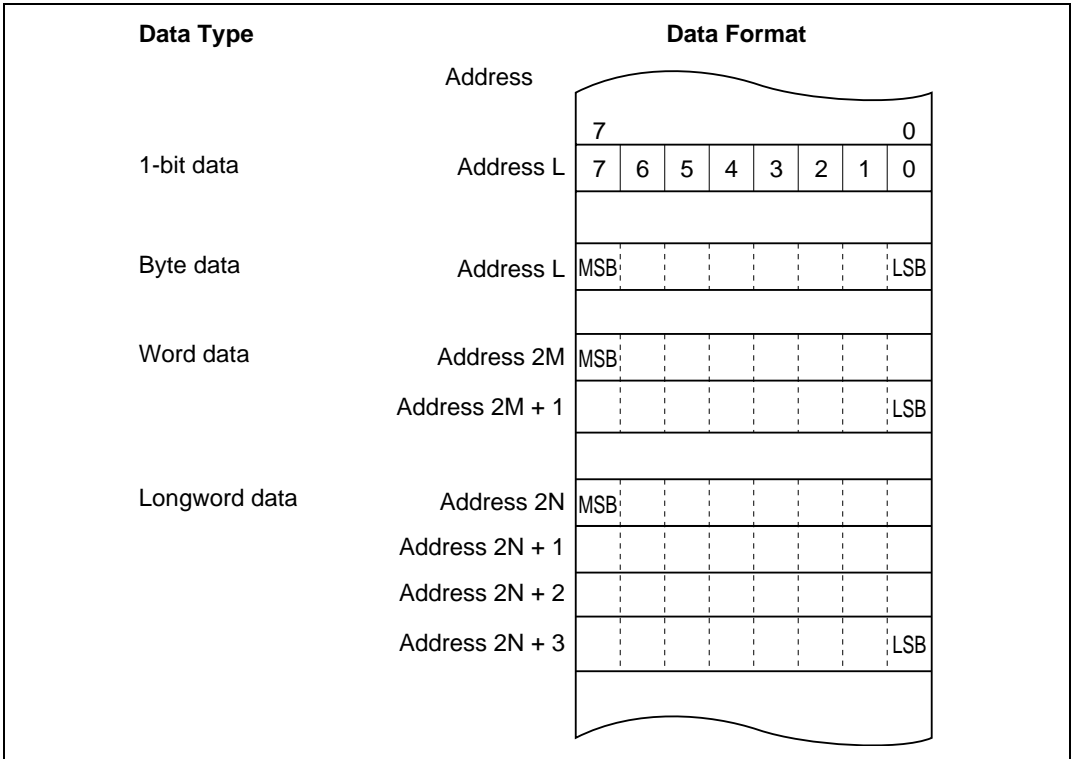




**Figure 1.10 General Register Data Formats (cont)**

### 1.5.2 Memory Data Formats

Figure 1.11 shows the data formats in memory. The CPU can access word data and longword data in memory, but word or longword data must begin at an even address. If an attempt is made to access word or longword data at an odd address, no address error occurs but the least significant bit of the address is regarded as 0, so the access starts at the preceding address. This also applies to instruction fetches.



**Figure 1.11 Memory Data Formats**

When the stack pointer (ER7) is used as an address register to access the stack, the operand size should be word size or longword size.

## 1.6 Instruction Set

### 1.6.1 Overview

The H8S/2600 CPU has 69 types of instructions, while the H8S/2000 CPU has 65 types. The instructions are classified by function as shown in table 1.1. For a detailed description of each instruction, see section 2.2, Instruction Descriptions.

**Table 1.1 Instruction Classification**

| Function              | Instructions  | Size | Types |
|-----------------------|---|------|-------|
| Data transfer         | MOV   | BWL  | 5     |
|                       | POP* <sup>2</sup> , PUSH* <sup>2</sup>  | WL   |       |
|                       | LDM, STM  | L    |       |
|                       | MOVFP, MOVTPE   | B    |       |
| Arithmetic operations | ADD, SUB, CMP, NEG  | BWL  | 19    |
|                       | ADDX, SUBX, DAA, DAS  | B    |       |
|                       | INC, DEC  | BWL  |       |
|                       | ADDS, SUBS  | L    |       |
|                       | MULXU, DIVXU, MULXS, DIVXS  | BW   |       |
|                       | EXTU, EXTS  | WL   |       |
|                       | TAS* <sup>4</sup>   | B    |       |
|                       | MAC, LDMAC, STMAC, CLRMAC* <sup>1</sup>   | —    |       |
| Logic operations      | AND, OR, XOR, NOT   | BWL  | 4     |
| Shift                 | SHAL, SHAR, SHLL, SHLR, ROTL, ROTR, ROTXL, ROTXR                                  | BWL  | 8     |
| Bit manipulation      | BSET, BCLR, BNOT, BTST, BLD, BILD, BST, BIST, BAND, BIAND, BOR, BIOR, BXOR, BIXOR | B    | 14    |
| Branch                | Bcc* <sup>3</sup> , JMP, BSR, JSR, RTS  | —    | 5     |
| System control        | TRAPA, RTE, SLEEP, LDC, STC, ANDC, ORC, XORC, NOP                                 | —    | 9     |
| Block data transfer   | EPMOV   | —    | 1     |

H8S/2600 CPU: Total 69 types      H8S/2000 CPU: Total 65 types

Legend: B: Byte size  
W: Word size  
L: Longword size

- Notes: 1. The MAC, LDMAC, STMAC, and CLRMAC instructions are supported only by the H8S/2600 CPU.
2. POP.W Rn and PUSH.W Rn are identical to MOV.W @SP+, Rn and MOV.W Rn, @-SP. POP.L ERn and PUSH.L ERn are identical to MOV.L @SP+, ERn and MOV.L ERn, @-SP.
3. Bcc is the generic designation of a conditional branch instruction.
4. Only register ER0, ER1, ER4, or ER5 should be used when using the TAS instruction.

## 1.6.2 Instructions and Addressing Modes

Table 1.2 indicates the combinations of instructions and addressing modes that the H8S/2600 CPU and H8S/2000 CPU can use.

**Table 1.2 Combinations of Instructions and Addressing Modes**

| Function              | Instruction     | Addressing Modes |     |      |            |            |             |       |        |        |        |           |            |       |   |   |
|-----------------------|-----------------|------------------|-----|------|------------|------------|-------------|-------|--------|--------|--------|-----------|------------|-------|---|---|
|                       |                 | #xx              | Rn  | @ERn | (d:16,ERn) | (d:32,ERn) | @-ERn/@ERn+ | @aa:8 | @aa:16 | @aa:24 | @aa:32 | @(d:8,PC) | @(d:16,PC) | @aa:8 | — |   |
| Data transfer         | MOV             | BWL              | BWL | BWL  | BWL        | BWL        | BWL         | B     | BWL    | —      | —      | —         | —          | —     | — | — |
|                       | POF, PUSH       | —                | —   | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
|                       | LDM, STM        | —                | —   | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
| Arithmetic operations | MOVEPE, MOVTPPE | —                | —   | —    | —          | —          | —           | B     | —      | —      | —      | —         | —          | —     | — | — |
|                       | ADD, CMP        | BWL              | BWL | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
|                       | SUB             | WL               | BWL | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
|                       | ADDX, SUBX      | B                | B   | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
|                       | ADDS, SUBS      | —                | L   | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
|                       | INC, DEC        | —                | BWL | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
|                       | DAA, DAS        | —                | B   | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
|                       | MULXU, DIVXU    | —                | BW  | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
|                       | MULXS, DIVXS    | —                | BW  | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
|                       | NEG             | —                | BWL | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
|                       | EXTU, EXTS      | —                | WL  | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — | — |
| TAS*2                 | —               | —                | B   | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — |   |
| MAC*1                 | —               | —                | —   | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — |   |
| CLRMAC*1              | —               | —                | —   | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — |   |
| LDMAC*1, STMAC*1      | —               | L                | —   | —    | —          | —          | —           | —     | —      | —      | —      | —         | —          | —     | — |   |

| Function            | Instruction     | Addressing Modes |     |      |             |             |            |       |        |        |        |           |            |       |   |
|---------------------|-----------------|------------------|-----|------|-------------|-------------|------------|-------|--------|--------|--------|-----------|------------|-------|---|
|                     |                 | #xx              | Rn  | @ERn | @(d:16,ERn) | @(d:32,ERn) | @-ERn/ERn+ | @aa:8 | @aa:16 | @aa:24 | @aa:32 | @(d:8,PC) | @(d:16,PC) | @aa:8 | — |
| Logic operations    | AND, OR, XOR    | BWL              | BWL | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |
|                     | NOT             | —                | BWL | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |
| Shift               |                 | —                | BWL | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |
| Bit manipulation    |                 | —                | B   | B    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |
| Branch              | Bcc, BSR        | —                | —   | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |
|                     | JMP, JSR        | —                | —   | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |
| System control      | RTS             | —                | —   | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |
|                     | TRAPA           | —                | —   | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |
|                     | RTE             | —                | —   | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |
|                     | SLEEP           | —                | —   | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |
|                     | LDC             | B                | B   | W    | W           | W           | W          | —     | —      | —      | —      | —         | —          | —     | — |
|                     | STC             | —                | B   | W    | W           | W           | W          | —     | —      | —      | —      | —         | —          | —     | — |
|                     | ANDC, ORC, XORC | B                | —   | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |
| NOP                 | —               | —                | —   | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     |   |
| Block data transfer |                 | —                | —   | —    | —           | —           | —          | —     | —      | —      | —      | —         | —          | —     | — |

Legend:

B: Byte

W: Word

L: Longword

Notes: 1. Supported only by the H8S/2600 CPU

2. Only register ER0, ER1, ER4, or ER5 should be used when using the TAS instruction.

### 1.6.3 Table of Instructions Classified by Function

Table 1.3 summarizes the instructions in each functional category. The notation used in table 1.3 is defined next.

#### Operation Notation

|                |  |
|----------------|--|
| Rd             | General register (destination)*                |
| Rs             | General register (source)*                     |
| Rn             | General register*                              |
| ERn            | General register (32-bit register)             |
| MAC            | Multiply-accumulate register (32-bit register) |
| (EAd)          | Destination operand                            |
| (EAs)          | Source operand                                 |
| EXR            | Extended control register                      |
| CCR            | Condition-code register                        |
| N              | N (negative) flag in CCR                       |
| Z              | Z (zero) flag in CCR                           |
| V              | V (overflow) flag in CCR                       |
| C              | C (carry) flag in CCR                          |
| PC             | Program counter                                |
| SP             | Stack pointer                                  |
| #IMM           | Immediate data                                 |
| disp           | Displacement                                   |
| +              | Addition                                       |
| -              | Subtraction                                    |
| ×              | Multiplication                                 |
| ÷              | Division                                       |
| ^              | Logical AND                                    |
| ∨              | Logical OR                                     |
| ⊕              | Logical exclusive OR                           |
| →              | Move   |
| ¬              | Logical not (logical complement)               |
| :8/:16/:24/:32 | 8-, 16-, 24-, or 32-bit length                 |

Note: \* General registers include 8-bit registers (R0H to R7H, R0L to R7L), 16-bit registers (R0 to R7, E0 to E7), and 32-bit registers (ER0 to ER7).

**Table 1.3 Instructions Classified by Function**

| Type          | Instruction | Size <sup>*1</sup> | Function  |
|---------------|-------------|--------------------|---|
| Data transfer | MOV         | B/W/L              | (EAs) → Rd, Rs → (EAd)<br>Moves data between two general registers or between a general register and memory, or moves immediate data to a general register. |
|               | MOVFPPE     | B                  | (EAs) → Rd<br>Moves external memory contents (addressed by @aa:16) to a general register in synchronization with an E clock.                                |
|               | MOVTPPE     | B                  | Rs → (EAs)<br>Moves general register contents to an external memory location (addressed by @aa:16) in synchronization with an E clock.                      |
|               | POP         | W/L                | @SP+ → Rn<br>Pops a register from the stack. POP.W Rn is identical to MOV.W @SP+, Rn. POP.L ERn is identical to MOV.L @SP+, ERn.                            |
|               | PUSH        | W/L                | Rn → @-SP<br>Pushes a register onto the stack. PUSH.W Rn is identical to MOV.W Rn, @-SP. PUSH.L ERn is identical to MOV.L ERn, @-SP.                        |
|               | LDM         | L                  | @SP+ → Rn (register list)<br>Pops two or more general registers from the stack.   |
|               | STM         | L                  | Rn (register list) → @-SP<br>Pushes two or more general registers onto the stack.   |

| Type                  | Instruction | Size*1 | Function  |
|-----------------------|-------------|--------|---|
| Arithmetic operations | ADD         | B/W/L  | $Rd \pm Rs \rightarrow Rd$ , $Rd \pm \#IMM \rightarrow Rd$  |
|                       | SUB         |        | Performs addition or subtraction on data in two general registers, or on immediate data and data in a general register. (Immediate byte data cannot be subtracted from byte data in a general register. Use the SUBX or ADD instruction.)               |
|                       | ADDX        | B      | $Rd \pm Rs \pm C \rightarrow Rd$ , $Rd \pm \#IMM \pm C \rightarrow Rd$  |
|                       | SUBX        |        | Performs addition or subtraction with carry or borrow on byte data in two general registers, or on immediate data and data in a general register.   |
|                       | INC         | B/W/L  | $Rd \pm 1 \rightarrow Rd$ , $Rd \pm 2 \rightarrow Rd$   |
|                       | DEC         |        | Increments or decrements a general register by 1 or 2. (Byte operands can be incremented or decremented by 1 only.)   |
|                       | ADDS        | L      | $Rd \pm 1 \rightarrow Rd$ , $Rd \pm 2 \rightarrow Rd$ , $Rd \pm 4 \rightarrow Rd$   |
|                       | SUBS        |        | Adds or subtracts the value 1, 2, or 4 to or from data in a 32-bit register.  |
|                       | DAA         | B      | $Rd$ decimal adjust $\rightarrow Rd$  |
|                       | DAS         |        | Decimal-adjusts an addition or subtraction result in a general register by referring to the CCR to produce 4-bit BCD data.  |
|                       | MULXU       | B/W    | $Rd \times Rs \rightarrow Rd$<br>Performs unsigned multiplication on data in two general registers: either 8 bits $\times$ 8 bits $\rightarrow$ 16 bits or 16 bits $\times$ 16 bits $\rightarrow$ 32 bits.  |
|                       | MULXS       | B/W    | $Rd \times Rs \rightarrow Rd$<br>Performs signed multiplication on data in two general registers: either 8 bits $\times$ 8 bits $\rightarrow$ 16 bits or 16 bits $\times$ 16 bits $\rightarrow$ 32 bits.  |
|                       | DIVXU       | B/W    | $Rd \div Rs \rightarrow Rd$<br>Performs unsigned division on data in two general registers: either 16 bits $\div$ 8 bits $\rightarrow$ 8-bit quotient and 8-bit remainder or 32 bits $\div$ 16 bits $\rightarrow$ 16-bit quotient and 16-bit remainder. |
|                       | DIVXS       | B/W    | $Rd \div Rs \rightarrow Rd$<br>Performs signed division on data in two general registers: either 16 bits $\div$ 8 bits $\rightarrow$ 8-bit quotient and 8-bit remainder or 32 bits $\div$ 16 bits $\rightarrow$ 16-bit quotient and 16-bit remainder.   |



| Type                  | Instruction    | Size* <sup>1</sup> | Function  |
|-----------------------|----------------|--------------------|---|
| Arithmetic operations | CMP            | B/W/L              | Rd – Rs, Rd – #IMM<br>Compares data in a general register with data in another general register or with immediate data, and sets CCR bits according to the result.  |
|                       | NEG            | B/W/L              | 0 – Rd → Rd<br>Takes the two's complement (arithmetic complement) of data in a general register.  |
|                       | EXTU           | W/L                | Rd (zero extension) → Rd<br>Extends the lower 8 bits of a 16-bit register to word size, or the lower 16 bits of a 32-bit register to longword size, by padding with zeros on the left.  |
|                       | EXTS           | W/L                | Rd (sign extension) → Rd<br>Extends the lower 8 bits of a 16-bit register to word size, or the lower 16 bits of a 32-bit register to longword size, by extending the sign bit.  |
|                       | TAS            | B                  | @ERd – 0, 1 → (<bit 7> of @ERd)* <sup>2</sup><br>Tests memory contents, and sets the most significant bit (bit 7) to 1.   |
|                       | MAC            | —                  | (EAs) × (EAd) + MAC → MAC<br>Performs signed multiplication on memory contents and adds the result to the multiply-accumulate register. The following operations can be performed:<br>16 bits × 16 bits + 32 bits → 32 bits, saturating<br>16 bits × 16 bits + 42 bits → 42 bits, non-saturating<br>Supported by H8S/2600 CPU only. |
|                       | CLRMAC         | —                  | 0 → MAC<br>Clears the multiply-accumulate register to zero.<br>Supported by H8S/2600 CPU only.  |
|                       | LDMAC<br>STMAC | L                  | Rs → MAC, MAC → Rd<br>Transfers data between a general register and the multiply-accumulate register.<br>Supported by H8S/2600 CPU only.  |

| Type             | Instruction | Size*1 | Function  |
|------------------|-------------|--------|---|
| Logic operations | AND         | B/W/L  | $Rd \wedge Rs \rightarrow Rd$ , $Rd \wedge \#IMM \rightarrow Rd$<br>Performs a logical AND operation on a general register and another general register or immediate data.          |
|                  | OR          | B/W/L  | $Rd \vee Rs \rightarrow Rd$ , $Rd \vee \#IMM \rightarrow Rd$<br>Performs a logical OR operation on a general register and another general register or immediate data.               |
|                  | XOR         | B/W/L  | $Rd \oplus Rs \rightarrow Rd$ , $Rd \oplus \#IMM \rightarrow Rd$<br>Performs a logical exclusive OR operation on a general register and another general register or immediate data. |
|                  | NOT         | B/W/L  | $\neg (Rd) \rightarrow (Rd)$<br>Takes the one's complement of general register contents.  |
| Shift operations | SHAL        | B/W/L  | $Rd \text{ (shift)} \rightarrow Rd$   |
|                  | SHAR        |        | Performs an arithmetic shift on general register contents.<br>1-bit or 2-bit shift is possible.   |
|                  | SHLL        | B/W/L  | $Rd \text{ (shift)} \rightarrow Rd$   |
|                  | SHLR        |        | Performs a logical shift on general register contents.<br>1-bit or 2-bit shift is possible.   |
|                  | ROTL        | B/W/L  | $Rd \text{ (rotate)} \rightarrow Rd$  |
|                  | ROTR        |        | Rotates general register contents.<br>1-bit or 2-bit rotation is possible.  |
|                  | ROTXL       | B/W/L  | $Rd \text{ (rotate)} \rightarrow Rd$  |
|                  | ROTXR       |        | Rotates general register contents through the carry bit.<br>1-bit or 2-bit rotation is possible.  |

| Type                          | Instruction | Size*1 | Function  |
|-------------------------------|-------------|--------|---|
| Bit-manipulation instructions | BSET        | B      | $1 \rightarrow (\text{<bit-No.> of <EAd>})$<br>Sets a specified bit in a general register or memory operand to 1. The bit number is specified by 3-bit immediate data or the lower three bits of a general register.  |
|                               | BCLR        | B      | $0 \rightarrow (\text{<bit-No.> of <EAd>})$<br>Clears a specified bit in a general register or memory operand to 0. The bit number is specified by 3-bit immediate data or the lower three bits of a general register.  |
|                               | BNOT        | B      | $\neg (\text{<bit-No.> of <EAd>}) \rightarrow (\text{<bit-No.> of <EAd>})$<br>Inverts a specified bit in a general register or memory operand. The bit number is specified by 3-bit immediate data or the lower three bits of a general register.               |
|                               | BTST        | B      | $\neg (\text{<bit-No.> of <EAd>}) \rightarrow Z$<br>Tests a specified bit in a general register or memory operand and sets or clears the Z flag accordingly. The bit number is specified by 3-bit immediate data or the lower three bits of a general register. |
|                               | BAND        | B      | $C \wedge (\text{<bit-No.> of <EAd>}) \rightarrow C$<br>ANDs the carry flag with a specified bit in a general register or memory operand and stores the result in the carry flag.   |
|                               | BIAND       | B      | $C \wedge \neg (\text{<bit-No.> of <EAd>}) \rightarrow C$<br>ANDs the carry flag with the inverse of a specified bit in a general register or memory operand and stores the result in the carry flag.<br>The bit number is specified by 3-bit immediate data.   |
|                               | BOR         | B      | $C \vee (\text{<bit-No.> of <EAd>}) \rightarrow C$<br>ORs the carry flag with a specified bit in a general register or memory operand and stores the result in the carry flag.  |
|                               | BIOR        | B      | $C \vee \neg (\text{<bit-No.> of <EAd>}) \rightarrow C$<br>ORs the carry flag with the inverse of a specified bit in a general register or memory operand and stores the result in the carry flag.<br>The bit number is specified by 3-bit immediate data.      |

| Type                          | Instruction | Size*1 | Function   |
|-------------------------------|-------------|--------|--|
| Bit-manipulation instructions | BXOR        | B      | $C \oplus (\text{<bit-No.> of <EAd>}) \rightarrow C$<br>Exclusive-ORs the carry flag with a specified bit in a general register or memory operand and stores the result in the carry flag.   |
|                               | BIXOR       | B      | $C \oplus \neg (\text{<bit-No.> of <EAd>}) \rightarrow C$<br>Exclusive-ORs the carry flag with the inverse of a specified bit in a general register or memory operand and stores the result in the carry flag.<br>The bit number is specified by 3-bit immediate data. |
|                               | BLD         | B      | $(\text{<bit-No.> of <EAd>}) \rightarrow C$<br>Transfers a specified bit in a general register or memory operand to the carry flag.  |
|                               | BILD        | B      | $\neg (\text{<bit-No.> of <EAd>}) \rightarrow C$<br>Transfers the inverse of a specified bit in a general register or memory operand to the carry flag.<br>The bit number is specified by 3-bit immediate data.  |
|                               | BST         | B      | $C \rightarrow (\text{<bit-No.> of <EAd>})$<br>Transfers the carry flag value to a specified bit in a general register or memory operand.  |
|                               | BIST        | B      | $\neg C \rightarrow (\text{<bit-No.> of <EAd>})$<br>Transfers the inverse of the carry flag value to a specified bit in a general register or memory operand.<br>The bit number is specified by 3-bit immediate data.  |

| Type                | Instruction | Size*1   | Function   |                            |                           |
|---------------------|-------------|--|--|----------------------------|---------------------------|
| Branch instructions | Bcc         | —  | Branches to a specified address if a specified condition is true. The branching conditions are listed below. |                            |                           |
|                     |             |  | <b>Mnemonic</b>  | <b>Description</b>         | <b>Condition</b>          |
|                     |             |  | BRA(BT)  | Always (true)              | Always                    |
|                     |             |  | BRN(BF)  | Never (false)              | Never                     |
|                     |             |  | BHI  | High                       | $C \vee Z = 0$            |
|                     |             |  | BLS  | Low or same                | $C \vee Z = 1$            |
|                     |             |  | BCC(BHS)   | Carry clear (high or same) | $C = 0$                   |
|                     |             |  | BCS(BLO)   | Carry set (low)            | $C = 1$                   |
|                     |             |  | BNE  | Not equal                  | $Z = 0$                   |
|                     |             |  | BEQ  | Equal                      | $Z = 1$                   |
|                     |             |  | BVC  | Overflow clear             | $V = 0$                   |
|                     |             |  | BVS  | Overflow set               | $V = 1$                   |
|                     |             |  | BPL  | Plus                       | $N = 0$                   |
|                     |             |  | BMI  | Minus                      | $N = 1$                   |
|                     |             |  | BGE  | Greater or equal           | $N \oplus V = 0$          |
|                     |             |  | BLT  | Less than                  | $N \oplus V = 1$          |
|                     |             |  | BGT  | Greater than               | $Z \vee (N \oplus V) = 0$ |
|                     |             |  | BLE  | Less or equal              | $Z \vee (N \oplus V) = 1$ |
| JMP                 | —           | Branches unconditionally to a specified address. |  |                            |                           |
| BSR                 | —           | Branches to a subroutine at a specified address. |  |                            |                           |
| JSR                 | —           | Branches to a subroutine at a specified address. |  |                            |                           |
| RTS                 | —           | Returns from a subroutine                        |  |                            |                           |

| Type                        | Instruction | Size*1  | Function  |
|-----------------------------|-------------|---|---|
| System control instructions | TRAPA       | —   | Starts trap-instruction exception handling.   |
|                             | RTE         | —   | Returns from an exception-handling routine.   |
|                             | SLEEP       | —   | Causes a transition to a power-down state.  |
|                             | LDC         | B/W   | (EAs) → CCR, (EAs) → EXR<br>Moves the source operand contents or immediate data to CCR or EXR. Although CCR and EXR are 8-bit registers, word-size transfers are performed between them and memory. The upper 8 bits are valid. |
|                             | STC         | B/W   | CCR → (EAd), EXR → (EAd)<br>Transfers CCR or EXR contents to a general register or memory. Although CCR and EXR are 8-bit registers, word-size transfers are performed between them and memory. The upper 8 bits are valid.     |
|                             | ANDC        | B   | CCR ∧ #IMM → CCR, EXR ∧ #IMM → EXR<br>Logically ANDs the CCR or EXR contents with immediate data.   |
|                             | ORC         | B   | CCR ∨ #IMM → CCR, EXR ∨ #IMM → EXR<br>Logically ORs the CCR or EXR contents with immediate data.  |
|                             | XORC        | B   | CCR ⊕ #IMM → CCR, EXR ⊕ #IMM → EXR<br>Logically exclusive-ORs the CCR or EXR contents with immediate data.  |
| NOP                         | —           | PC + 2 → PC<br>Only increments the program counter. |   |

| Type                            | Instruction | Size*1 | Function  |
|---------------------------------|-------------|--------|---|
| Block data transfer instruction | EPMOV.B     | —      | if R4L $\neq$ 0 then<br>Repeat @ER5+ $\rightarrow$ @ER6+<br>R4L - 1 $\rightarrow$ R4L<br>Until R4L = 0<br>else next;  |
|                                 | EPMOV.W     | —      | if R4 $\neq$ 0 then<br>Repeat @ER5+ $\rightarrow$ @ER6+<br>R4 - 1 $\rightarrow$ R4<br>Until R4 = 0<br>else next;  |
|                                 |             |        | Transfers a data block according to parameters set in general registers R4L or R4, ER5, and ER6.<br>R4L or R4: size of block (bytes)<br>ER5: starting source address<br>ER6: starting destination address<br>Execution of the next instruction begins as soon as the transfer is completed. |

Notes: 1. Size refers to the operand size.

B: Byte

W: Word

L: Longword

2. Only register ER0, ER1, ER4, or ER5 should be used when using the TAS instruction.

### 1.6.4 Basic Instruction Formats

The H8S/2600 or H8S/2000 instructions consist of 2-byte (1-word) units. An instruction consists of an operation field (op field), a register field (r field), an effective address extension (EA field), and a condition field (cc).

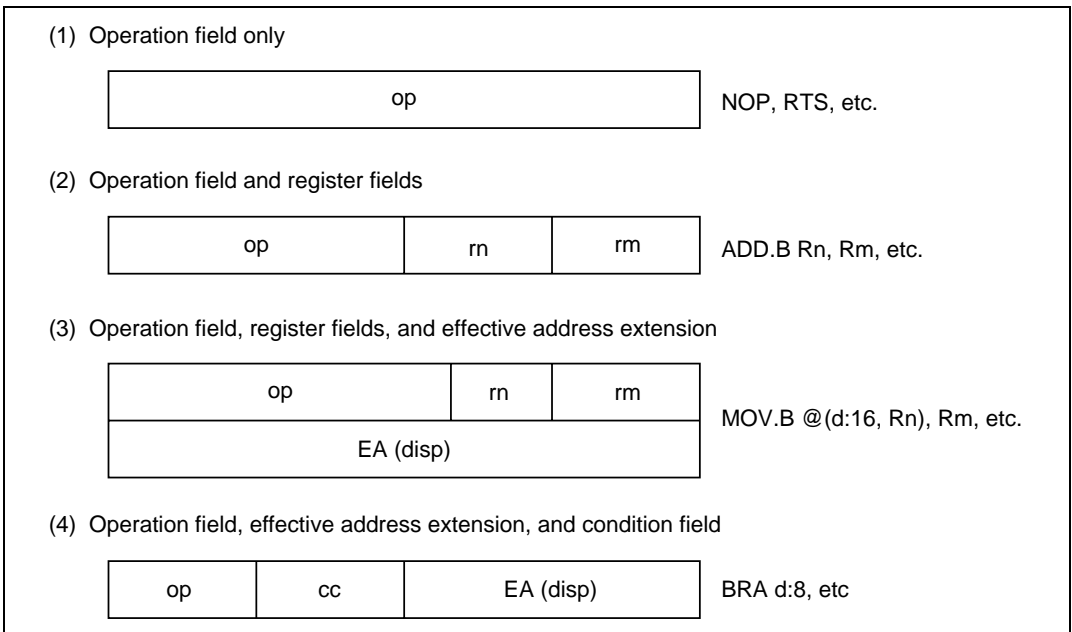
**Operation Field:** Indicates the function of the instruction, the addressing mode, and the operation to be carried out on the operand. The operation field always includes the first four bits of the instruction. Some instructions have two operation fields.

**Register Field:** Specifies a general register. Address registers are specified by 3 bits, data registers by 3 bits or 4 bits. Some instructions have two register fields. Some have no register field.

**Effective Address Extension:** Eight, 16, or 32 bits specifying immediate data, an absolute address, or a displacement.

**Condition Field:** Specifies the branching condition of Bcc instructions.

Figure 1.12 shows examples of instruction formats.



**Figure 1.12 Instruction Formats**



## 1.7 Addressing Modes and Effective Address Calculation

### (1) Addressing Modes

The CPUs support the eight addressing modes listed in table 1.4. Each instruction uses a subset of these addressing modes. Arithmetic and logic instructions can use the register direct and immediate modes. Data transfer instructions can use all addressing modes except program-counter relative and memory indirect. Bit manipulation instructions use register direct, register indirect, or absolute addressing mode to specify an operand, and register direct (BSET, BCLR, BNOT, and BTST instructions) or immediate (3-bit) addressing mode to specify a bit number in the operand.

**Table 1.4 Addressing Modes**

| No. | Addressing Mode                       | Symbol                     |
|-----|---------------------------------------|----------------------------|
| 1   | Register direct                       | Rn                         |
| 2   | Register indirect                     | @ERn                       |
| 3   | Register indirect with displacement   | @(d:16,ERn)/@(d:32,ERn)    |
| 4   | Register indirect with post-increment | @ERn+                      |
|     | Register indirect with pre-decrement  | @-ERn                      |
| 5   | Absolute address                      | @aa:8/@aa:16/@aa:24/@aa:32 |
| 6   | Immediate                             | #xx:8/#xx:16/#xx:32        |
| 7   | Program-counter relative              | @(d:8,PC)/@(d:16,PC)       |
| 8   | Memory indirect                       | @@aa:8                     |

**1. Register Direct—Rn:** The register field of the instruction specifies an 8-, 16-, or 32-bit general register containing the operand. R0H to R7H and R0L to R7L can be specified as 8-bit registers. R0 to R7 and E0 to E7 can be specified as 16-bit registers. ER0 to ER7 can be specified as 32-bit registers.

**2. Register Indirect—@ERn:** The register field of the instruction code specifies an address register (ERn) which contains the address of the operand in memory. If the address is a program instruction address, the lower 24 bits are valid and the upper 8 bits are all assumed to be 0 (H'00).

**3. Register Indirect with Displacement—@(d:16, ERn) or @(d:32, ERn):** A 16-bit or 32-bit displacement contained in the instruction is added to an address register (ERn) specified by the register field of the instruction, and the sum gives the address of a memory operand. A 16-bit displacement is sign-extended when added.

#### 4. Register Indirect with Post-Increment or Pre-Decrement—@ERn+ or @-ERn:

- Register indirect with post-increment—@ERn+

The register field of the instruction code specifies an address register (ERn) which contains the address of a memory operand. After the operand is accessed, 1, 2, or 4 is added to the address register contents and the sum is stored in the address register. The value added is 1 for byte access, 2 for word access, or 4 for longword access. For word or longword access, the register value should be even.

- Register indirect with pre-decrement—@-ERn

The value 1, 2, or 4 is subtracted from an address register (ERn) specified by the register field in the instruction code, and the result becomes the address of a memory operand. The result is also stored in the address register. The value subtracted is 1 for byte access, 2 for word access, or 4 for longword access. For word or longword access, the register value should be even.

**5. Absolute Address—@aa:8, @aa:16, @aa:24, or @aa:32:** The instruction code contains the absolute address of a memory operand. The absolute address may be 8 bits long (@aa:8), 16 bits long (@aa:16), 24 bits long (@aa:24), or 32 bits long (@aa:32).

To access data, the absolute address should be 8 bits (@aa:8), 16 bits (@aa:16), or 32 bits (@aa:32) long. For an 8-bit absolute address, the upper 24 bits are all assumed to be 1 (H'FFFFFF). For a 16-bit absolute address the upper 16 bits are a sign extension. A 32-bit absolute address can access the entire address space.

A 24-bit absolute address (@aa:24) indicates the address of a program instruction. The upper 8 bits are all assumed to be 0 (H'00).

Table 1.5 indicates the accessible absolute address ranges.

**Table 1.5 Absolute Address Access Ranges**

| Absolute Address            |                  | Normal Mode      | Advanced Mode  |
|-----------------------------|------------------|------------------|--|
| Data address                | 8 bits (@aa:8)   | H'FF00 to H'FFFF | H'FFFFFF00 to H'FFFFFFF                              |
|                             | 16 bits (@aa:16) | H'0000 to H'FFFF | H'00000000 to H'00007FFF,<br>H'FFFF8000 to H'FFFFFFF |
|                             | 32 bits (@aa:32) |                  | H'00000000 to H'FFFFFFF                              |
| Program instruction address | 24 bits (@aa:24) |                  | H'00000000 to H'00FFFFFF                             |

For further details on the accessible range, refer to the relevant microcontroller hardware manual.

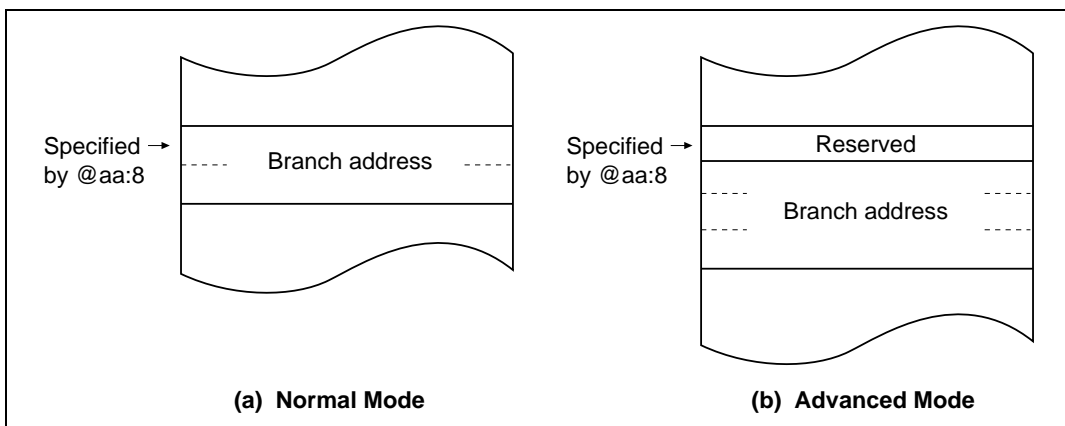
**6. Immediate—#xx:8, #xx:16, or #xx:32:** The instruction contains 8-bit (#xx:8), 16-bit (#xx:16), or 32-bit (#xx:32) immediate data as an operand.

The ADDS, SUBS, INC, and DEC instructions contain immediate data implicitly. Some bit manipulation instructions contain 3-bit immediate data in the instruction code, specifying a bit number. The TRAPA instruction contains 2-bit immediate data in its instruction code, specifying a vector address.

**7. Program-Counter Relative—@(d:8, PC) or @(d:16, PC):** This mode is used in the Bcc and BSR instructions. An 8-bit or 16-bit displacement contained in the instruction is sign-extended and added to the 24-bit PC contents to generate a branch address. Only the lower 24 bits of this branch address are valid; the upper 8 bits are all assumed to be 0 (H'00). The PC value to which the displacement is added is the address of the first byte of the next instruction, so the possible branching range is  $-126$  to  $+128$  bytes ( $-63$  to  $+64$  words) or  $-32766$  to  $+32768$  bytes ( $-16383$  to  $+16384$  words) from the branch instruction. The resulting value should be an even number.

**8. Memory Indirect—@@aa:8:** This mode can be used by the JMP and JSR instructions. The second byte of the instruction specifies a memory operand by an 8-bit absolute address. This memory operand contains a branch address. The upper bits of the absolute address are all assumed to be 0, so the address range is 0 to 255 (H'0000 to H'00FF in normal mode, H'00000000 to H'000000FF in advanced mode). In normal mode the memory operand is a word operand and the branch address is 16 bits long. In advanced mode the memory operand is a longword operand, the first byte of which is assumed to be all 0 (H'00).

Note that the first part of the address range is also the exception vector area. For further details refer to the relevant microcontroller hardware manual.



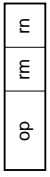

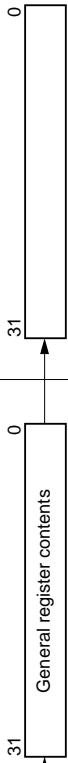
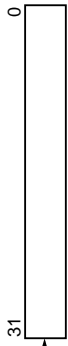

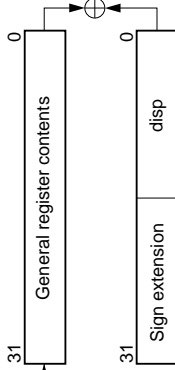
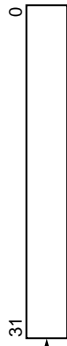


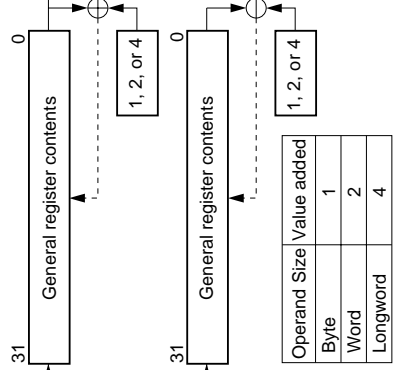

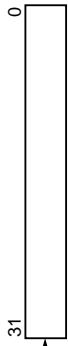
**Figure 1.13 Branch Address Specification in Memory Indirect Mode**




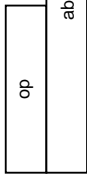

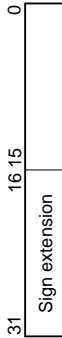



If an odd address is specified in word or longword memory access, or as a branch address, the least significant bit is regarded as 0, causing data to be accessed or an instruction code to be fetched at the address preceding the specified address. (For further information, see section 1.5.2, Memory Data Formats.)

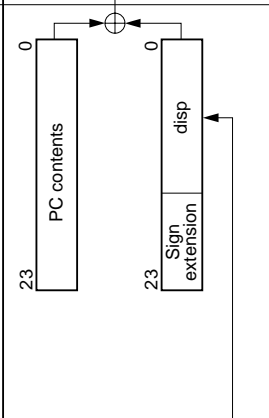
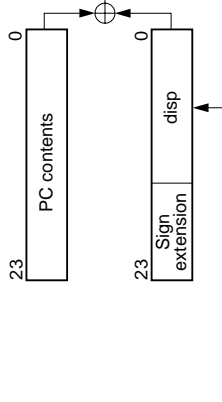
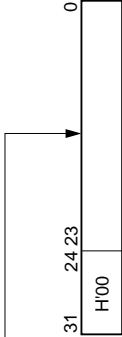
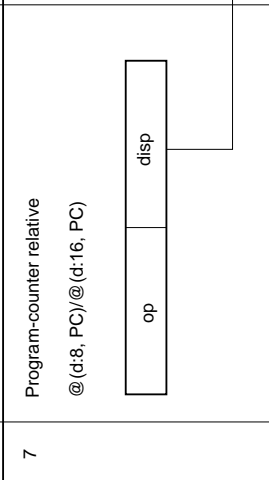
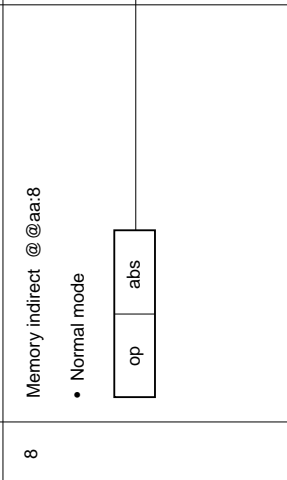
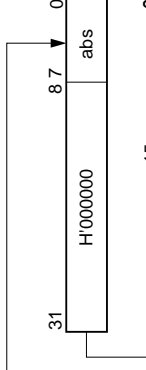
## **(2) Effective Address Calculation**

Table 1.6 indicates how effective addresses are calculated in each addressing mode. In normal mode the upper 8 bits of the effective address are ignored in order to generate a 16-bit address.

Table 1.6 Effective Address Calculation

| No.          | Addressing Mode and Instruction Format  | Effective Address Calculation   | Effective Address (EA)  |             |      |   |      |   |          |   |  |
|--------------|---|---|---|-------------|------|---|------|---|----------|---|--|
| 1            | Register direct (Rn)<br>   |   | Operand is general register contents.   |             |      |   |      |   |          |   |  |
| 2            | Register indirect (@ERn)<br>   |    |  |             |      |   |      |   |          |   |  |
| 3            | Register indirect with displacement<br>@d:16, ERn) or @d:32, ERn)<br>  |    |  |             |      |   |      |   |          |   |  |
| 4            | Register indirect with post-increment or pre-decrement<br>• Register indirect with post-increment @ERn+<br><br>• Register indirect with pre-decrement @-ERn<br> |  <table border="1" data-bbox="957 678 1065 917"> <thead> <tr> <th>Operand Size</th> <th>Value added</th> </tr> </thead> <tbody> <tr> <td>Byte</td> <td>1</td> </tr> <tr> <td>Word</td> <td>2</td> </tr> <tr> <td>Longword</td> <td>4</td> </tr> </tbody> </table> | Operand Size  | Value added | Byte | 1 | Word | 2 | Longword | 4 | <br> |
| Operand Size | Value added   |   |   |             |      |   |      |   |          |   |  |
| Byte         | 1   |   |   |             |      |   |      |   |          |   |  |
| Word         | 2   |   |   |             |      |   |      |   |          |   |  |
| Longword     | 4   |   |   |             |      |   |      |   |          |   |  |

| No. | Addressing Mode and Instruction Format   | Effective Address Calculation | Effective Address (EA)  |
|-----|--|-------------------------------|---|
| 5   | <p>Absolute address</p> <p>@aa:8</p>  <p>@aa:16</p>  <p>@aa:24</p>  <p>@aa:32</p>  |                               |     |
| 6   | <p>Immediate #xx:8/#xx:16/#xx:32</p>   |                               | <p>Operand is immediate data.</p>   |

| No. | Addressing Mode and Instruction Format  | Effective Address Calculation   | Effective Address (EA)   |
|-----|---|---|--|
| 7   | <p>Program-counter relative<br/>@ (d:8, PC)/@ (d:16, PC)</p>                                   |    |    |
| 8   | <p>Memory indirect @aa:8</p> <ul style="list-style-type: none"> <li>• Normal mode</li> </ul>  |   |   |
|     | <ul style="list-style-type: none"> <li>• Advanced mode</li> </ul>                            |  |  |





## Section 2 Instruction Descriptions

### 2.1 Tables and Symbols

This section explains how to read the tables in section 2.2, describing each instruction. Note that the descriptions of some instructions extend over more than one page.

|  |                    |
|--|--------------------|
| [1] Mnemonic (Full Name)                                       | [2] Type           |
| [3] Operation  | [6] Condition Code |
| [4] Assembly-Language Format                                   |                    |
| [5] Operand Size   |                    |
| [7] Description  |                    |
| [8] Available Registers  |                    |
| [9] Operand Format and Number of States Required for Execution |                    |
| [10] Notes   |                    |

**[1] Mnemonic (Full Name):** Gives the full and mnemonic names of the instruction.

**[2] Type:** Indicates the type of instruction.

**[3] Operation:** Describes the instruction in symbolic notation. (See section 2.1.2, Operation.)

**[4] Assembly-Language Format:** Indicates the assembly-language format of the instruction. (See section 2.1.1, Assembler Format.)

**[5] Operand Size:** Indicates the available operand sizes.

**[6] Condition Code:** Indicates the effect of instruction execution on the flag bits in the CCR. (See section 2.1.3, Condition Code.)

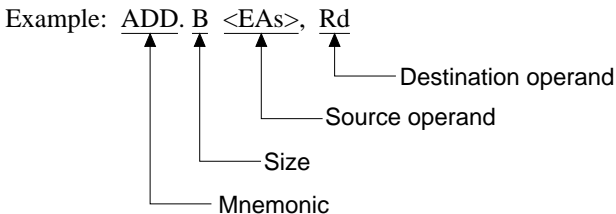
**[7] Description:** Describes the operation of the instruction in detail.

**[8] Available Registers:** Indicates which registers can be specified in the register field of the instruction.

**[9] Operand Format and Number of States Required for Execution:** Shows the addressing modes and instruction format together with the number of states required for execution.

**[10] Notes:** Gives notes concerning execution of the instruction.

### 2.1.1 Assembly-Language Format



The operand size is byte (B), word (W), or longword (L). Some instructions are restricted to a limited set of operand sizes.

The symbol <EA> indicates that two or more addressing modes can be used. The H8S/2600 CPU supports the eight addressing modes listed next. Effective address calculation is described in section 1.7, Addressing Modes and Effective Address Calculation.

| Symbol                     | Addressing Mode  |
|----------------------------|--|
| Rn                         | Register direct  |
| @ERn                       | Register indirect                                      |
| @(d:16, ERn)/@(d:32, ERn)  | Register indirect with displacement (16-bit or 32-bit) |
| @ERn+/@-ERn                | Register indirect with post-increment or pre-decrement |
| @aa:8/@aa:16/@aa:24/@aa:32 | Absolute address (8-bit, 16-bit, 24-bit, or 32-bit)    |
| #xx:8/#xx:16/#xx:32        | Immediate (8-bit, 16-bit, or 32-bit)                   |
| @(d:8, PC)/@(d:16, PC)     | Program-counter relative (8-bit or 16-bit)             |
| @@aa:8                     | Memory indirect  |

The suffixes :8, :16, :24, and :32 may be omitted. In particular, if the :8, :16, :24, or :32 designation is omitted in an absolute address or displacement, the assembler will optimize the length according to the value range. For details, refer to the H8S, H8/300 Series cross assembler user's manual.

Note: “:2” and “:3” in “#xx (:2)” and “#xx (:3)” indicate the specifiable bit length. Do not include (:2) or (:3) in the assembler notation.

Example: TRAPA #3

## 2.1.2 Operation

The symbols used in the operation descriptions are defined as follows.

|                    |   |
|--------------------|---|
| Rd                 | General register (destination)*   |
| Rs                 | General register (source)*  |
| Rn                 | General register*   |
| ERn                | General register (32-bit register)  |
| MAC                | Multiply-accumulate register (32-bit register)  |
| (EAd)              | Destination operand   |
| (EAs)              | Source operand  |
| EXR                | Extended control register   |
| CCR                | Condition-code register   |
| N                  | N (negative) flag in CCR  |
| Z                  | Z (zero) flag in CCR  |
| V                  | V (overflow) flag in CCR  |
| C                  | C (carry) flag in CCR   |
| PC                 | Program counter   |
| SP                 | Stack pointer   |
| #IMM               | Immediate data  |
| disp               | Displacement  |
| +                  | Add   |
| −                  | Subtract  |
| ×                  | Multiply  |
| ÷                  | Divide  |
| ^                  | Logical AND   |
| ∨                  | Logical OR  |
| ⊕                  | Logical exclusive OR  |
| →                  | Transfer from the operand on the left to the operand on the right, or transition from the state on the left to the state on the right |
| ¬                  | Logical NOT (logical complement)  |
| ( ) < >            | Contents of effective address of the operand  |
| :8/:16/<br>:24/:32 | 8-, 16-, 24-, or 32-bit length  |

Note: \* General registers include 8-bit registers (R0H to R7H and R0L to R7L), 16-bit registers (R0 to R7 and E0 to E7), and 32-bit registers (ER0 to ER7).

### 2.1.3 Condition Code

The symbols used in the condition-code description are defined as follows.

| Symbol | Meaning  |
|--------|--|
| ↕      | Changes according to the result of instruction execution |
| *      | Undetermined (no guaranteed value)                       |
| 0      | Always cleared to 0                                      |
| 1      | Always set to 1  |
| —      | Not affected by execution of the instruction             |
| Δ      | Varies depending on conditions; see the notes            |

---

For details on changes of the condition code, see section 2.8, Condition Code Modification.

### 2.1.4 Instruction Format

The symbols used in the instruction format descriptions are listed below.

| Symbol        | Meaning   |
|---------------|---|
| IMM           | Immediate data (2, 3, 8, 16, or 32 bits)  |
| abs           | Absolute address (8, 16, 24, or 32 bits)  |
| disp          | Displacement (8, 16, or 32 bits)  |
| rs, rd, rn    | Register field (4 bits). The symbols rs, rd, and rn correspond to operand symbols Rs, Rd, and Rn.       |
| ers, erd, ern | Register field (3 bits). The symbols ers, erd, and ern correspond to operand symbols ERs, ERd, and ERn. |

---

## 2.1.5 Register Specification

**Address Register Specification:** When a general register is used as an address register [ $@ERn$ ,  $@(d:16, ERn)$ ,  $@(d:32, ERn)$ ,  $@ERn+$ , or  $@-ERn$ ], the register is specified by a 3-bit register field (ers or erd).

**Data Register Specification:** A general register can be used as a 32-bit, 16-bit, or 8-bit data register.

When used as a 32-bit register, it is specified by a 3-bit register field (ers, erd, or ern).

When used as a 16-bit register, it is specified by a 4-bit register field (rs, rd, or rn). The lower 3 bits specify the register number. The upper bit is set to 1 to specify an extended register (En) or cleared to 0 to specify a general register (Rn).

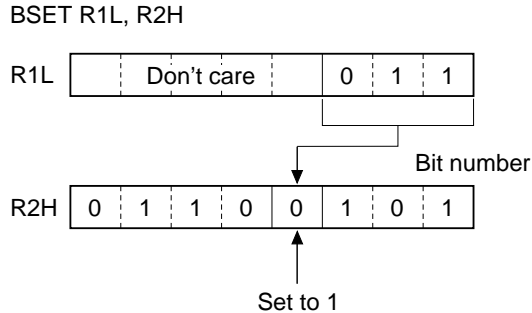
When used as an 8-bit register, it is specified by a 4-bit register field (rs, rd, or rn). The lower 3 bits specify the register number. The upper bit is set to 1 to specify a low register (RnL) or cleared to 0 to specify a high register (RnH). This is shown next.

| Address Register<br>32-Bit Register |                  | 16-Bit Register |                  | 8-Bit Register |                  |
|-------------------------------------|------------------|-----------------|------------------|----------------|------------------|
| Register Field                      | General Register | Register Field  | General Register | Register Field | General Register |
| 000                                 | ER0              | 0000            | R0               | 0000           | R0H              |
| 001                                 | ER1              | 0001            | R1               | 0001           | R1H              |
| .                                   | .                | .               | .                | .              | .                |
| .                                   | .                | .               | .                | .              | .                |
| 111                                 | ER7              | 0111            | R7               | 0111           | R7H              |
|                                     |                  | 1000            | E0               | 1000           | R0L              |
|                                     |                  | 1001            | E1               | 1001           | R1L              |
|                                     |                  | .               | .                | .              | .                |
|                                     |                  | .               | .                | .              | .                |
|                                     |                  | 1111            | E7               | 1111           | R7L              |

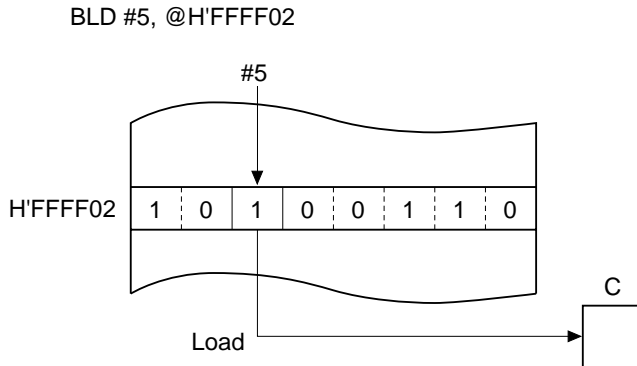
### 2.1.6 Bit Data Access in Bit Manipulation Instructions

Bit data is accessed as the n-th bit ( $n = 0, 1, 2, 3, \dots, 7$ ) of a byte operand in a general register or memory. The bit number is given by 3-bit immediate data, or by the lower 3 bits of a general register value.

Example 1: To set bit 3 in R2H to 1



Example 2: To load bit 5 at address H'FFFF02 into the bit accumulator



The operand size and addressing mode are as indicated for register or memory operand data.

## 2.2 Instruction Descriptions

The instructions are described starting in section 2.2.1.

**2.2.1 (1) ADD (B)****ADD (ADD Binary)****Add Binary****Operation**

Rd + (EAs) → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

ADD .B &lt;EAs&gt;, Rd

H: Set to 1 if there is a carry at bit 3;  
otherwise cleared to 0.N: Set to 1 if the result is negative; otherwise  
cleared to 0.Z: Set to 1 if the result is zero; otherwise  
cleared to 0.V: Set to 1 if an overflow occurs; otherwise  
cleared to 0.C: Set to 1 if there is a carry at bit 7;  
otherwise cleared to 0.**Operand Size**

Byte

**Description**

This instruction adds the source operand to the contents of an 8-bit register Rd (destination operand) and stores the result in the 8-bit register Rd.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

Rs: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands  | Instruction Format |          |          |          | No. of States |
|-----------------|----------|-----------|--------------------|----------|----------|----------|---------------|
|                 |          |           | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | ADD.B    | #xx:8, Rd | 8                  | rd       | IMM      |          | 1             |
| Register direct | ADD.B    | Rs, Rd    | 0                  | 8        | rs       | rd       | 1             |

**Notes**



**2.2.1 (2) ADD (W)****ADD (ADD Binary)****Add Binary****Operation**

Rd + (EAs) → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

ADD.W &lt;EAs&gt;, Rd

- H: Set to 1 if there is a carry at bit 11; otherwise cleared to 0.
- N: Set to 1 if the result is negative; otherwise cleared to 0.
- Z: Set to 1 if the result is zero; otherwise cleared to 0.
- V: Set to 1 if an overflow occurs; otherwise cleared to 0.
- C: Set to 1 if there is a carry at bit 15; otherwise cleared to 0.

**Operand Size**

Word

**Description**

This instruction adds the source operand to the contents of a 16-bit register Rd (destination operand) and stores the result in the 16-bit register Rd.

**Available Registers**

Rd: R0 to R7, E0 to E7

Rs: R0 to R7, E0 to E7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands   | Instruction Format |          |          |          | No. of States |
|-----------------|----------|------------|--------------------|----------|----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | ADD.W    | #xx:16, Rd | 7   9              | 1   rd   | IMM      |          | 2             |
| Register direct | ADD.W    | Rs, Rd     | 0   9              | rs   rd  |          |          | 1             |

**Notes**

**2.2.1 (3) ADD (L)****ADD (ADD Binary)****Add Binary****Operation**

ERd + (EAs) → ERd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

ADD .L &lt;EAs&gt;, ERd

H: Set to 1 if there is a carry at bit 27; otherwise cleared to 0.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Set to 1 if there is a carry at bit 31; otherwise cleared to 0.

**Operand Size**

Longword

**Description**

This instruction adds the source operand to the contents of a 32-bit register ERd (destination operand) and stores the result in the 32-bit register ERd.

**Available Registers**

ERd: ER0 to ER7

ERs: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands    | Instruction Format |          |   |          |          |          | No. of States |          |   |   |
|-----------------|----------|-------------|--------------------|----------|---|----------|----------|----------|---------------|----------|---|---|
|                 |          |             | 1st byte           | 2nd byte |   | 3rd byte | 4th byte | 5th byte |               | 6th byte |   |   |
| Immediate       | ADD.L    | #xx:32, ERd | 7                  | A        | 1 | 0        | erd      | IMM      |               |          | 3 |   |
| Register direct | ADD.L    | ERs, ERd    | 0                  | A        | 1 | ers      | 0        | erd      |               |          |   | 1 |

**Notes**

## 2.2.2 ADDS

### ADDS (ADD with Sign extension)

### Add Binary Address Data

#### Operation

Rd + 1 → ERd

Rd + 2 → ERd

Rd + 4 → ERd

#### Condition Code

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

#### Assembly-Language Format

ADDS #1, ERd

ADDS #2, ERd

ADDS #4, ERd

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

#### Operand Size

Longword

#### Description

This instruction adds the immediate value 1, 2, or 4 to the contents of a 32-bit register ERd (destination operand). Unlike the ADD instruction, it does not affect the condition code flags.

#### Available Registers

ERd: ER0 to ER7

#### Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ADDS     | #1, ERd  | 0 B                | 0 0 erd  |          |          | 1             |
| Register direct | ADDS     | #2, ERd  | 0 B                | 8 0 erd  |          |          | 1             |
| Register direct | ADDS     | #4, ERd  | 0 B                | 9 0 erd  |          |          | 1             |

#### Notes

## 2.2.3 ADDX

ADDX (ADD with eXtend carry)

Add with Carry

**Operation**

Rd + (EAs) + C → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

ADDX &lt;EAs&gt;, Rd

H: Set to 1 if there is a carry at bit 3;  
otherwise cleared to 0.N: Set to 1 if the result is negative; otherwise  
cleared to 0.Z: Set to 1 if the result is zero; otherwise  
cleared to 0.V: Set to 1 if an overflow occurs; otherwise  
cleared to 0.C: Set to 1 if there is a carry at bit 7;  
otherwise cleared to 0.**Operand Size**

Byte

**Description**

This instruction adds the source operand and carry flag to the contents of an 8-bit register Rd (destination operand) and stores the result in the 8-bit register Rd.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

Rs: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands  | Instruction Format |          |          |          | No. of States |
|-----------------|----------|-----------|--------------------|----------|----------|----------|---------------|
|                 |          |           | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | ADDX     | #xx:8, Rd | 9                  | rd       | IMM      |          | 1             |
| Register direct | ADDX     | Rs, Rd    | 0                  | E        | rs       | rd       | 1             |

**Notes**

## 2.2.4 (1) AND (B)

## AND (AND logical)

## Logical AND

## Operation

Rd  $\wedge$  (EAs)  $\rightarrow$  Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

## Assembly-Language Format

AND.B &lt;EAs&gt;, Rd

- H: Previous value remains unchanged.  
 N: Set to 1 if the result is negative; otherwise cleared to 0.  
 Z: Set to 1 if the result is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

## Operand Size

Byte

## Description

This instruction ANDs the source operand with the contents of an 8-bit register Rd (destination operand) and stores the result in the 8-bit register Rd.

## Available Registers

Rd: R0L to R7L, R0H to R7H

Rs: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands  | Instruction Format |          |          |          | No. of States |
|-----------------|----------|-----------|--------------------|----------|----------|----------|---------------|
|                 |          |           | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | AND.B    | #xx:8, Rd | E   rd             | IMM      |          |          | 1             |
| Register direct | AND.B    | Rs, Rd    | 1   6              | rs   rd  |          |          | 1             |

## Notes

## 2.2.4 (2) AND (W)

## AND (AND logical)

## Logical AND

## Operation

$$Rd \wedge (EAs) \rightarrow Rd$$

## Condition Code

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | 0 | — |

## Assembly-Language Format

$$AND.W <EAs>, Rd$$

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

## Operand Size

Word

## Description

This instruction ANDs the source operand with the contents of a 16-bit register Rd (destination operand) and stores the result in the 16-bit register Rd.

## Available Registers

Rd: R0 to R7, E0 to E7

Rs: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands   | Instruction Format |          |          |          | No. of States |   |
|-----------------|----------|------------|--------------------|----------|----------|----------|---------------|---|
|                 |          |            | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |   |
| Immediate       | AND.W    | #xx:16, Rd | 7                  | 9        | 6        | rd       | IMM           | 2 |
| Register direct | AND.W    | Rs, Rd     | 6                  | 6        | rs       | rd       |               | 1 |

## Notes

## 2.2.4 (3) AND (L)

## AND (AND logical)

## Logical AND

## Operation

 $ERd \wedge (EAs) \rightarrow ERd$ 

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

## Assembly-Language Format

`AND.L <EAs>, ERd`

- H: Previous value remains unchanged.  
 N: Set to 1 if the result is negative; otherwise cleared to 0.  
 Z: Set to 1 if the result is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

## Operand Size

Longword

## Description

This instruction ANDs the source operand with the contents of a 32-bit register ERd (destination operand) and stores the result in the 32-bit register ERd.

## Available Registers

ERd: ER0 to ER7

ERs: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands    | Instruction Format |   |          |   |          |          | No. of States |          |          |     |   |
|-----------------|----------|-------------|--------------------|---|----------|---|----------|----------|---------------|----------|----------|-----|---|
|                 |          |             | 1st byte           |   | 2nd byte |   | 3rd byte | 4th byte |               | 5th byte | 6th byte |     |   |
| Immediate       | AND.L    | #xx:32, ERd | 7                  | A | 6        | 0 | erd      | IMM      |               |          | 3        |     |   |
| Register direct | AND.L    | ERs, ERd    | 0                  | 1 | F        | 0 | 6        | 6        | 0             | ers      | 0        | erd | 2 |

## Notes

## 2.2.5 (1) ANDC

ANDC (AND Control register)

Logical AND with CCR

**Operation**CCR  $\wedge$  #IMM  $\rightarrow$  CCR**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| ↑ | ↑  | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

ANDC #xx:8, CCR

**Operand Size**

Byte

I: Stores the corresponding bit of the result.

UI: Stores the corresponding bit of the result.

H: Stores the corresponding bit of the result.

U: Stores the corresponding bit of the result.

N: Stores the corresponding bit of the result.

Z: Stores the corresponding bit of the result.

V: Stores the corresponding bit of the result.

C: Stores the corresponding bit of the result.

**Description**

This instruction ANDs the contents of the condition-code register (CCR) with immediate data and stores the result in the condition-code register. No interrupt requests, including NMI, are accepted immediately after execution of this instruction.

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands   | Instruction Format |          |          |          | No. of States |
|-----------------|----------|------------|--------------------|----------|----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | ANDC     | #xx:8, CCR | 0 6                | IMM      |          |          | 1             |

**Notes**



## 2.2.5 (2) ANDC

## ANDC (AND Control register)

## Logical AND with EXR

## Operation

$$\text{EXR} \wedge \# \text{IMM} \rightarrow \text{EXR}$$

## Condition Code

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

## Assembly-Language Format

$$\text{ANDC} \# \text{xx}:8, \text{EXR}$$

- H: Previous value remains unchanged.
- N: Previous value remains unchanged.
- Z: Previous value remains unchanged.
- V: Previous value remains unchanged.
- C: Previous value remains unchanged.

## Operand Size

Byte

## Description

This instruction ANDs the contents of the extended control register (EXR) with immediate data and stores the result in the extended control register. No interrupt requests, including NMI, are accepted for three states after execution of this instruction.

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands   | Instruction Format |          |          |          | No. of States |
|-----------------|----------|------------|--------------------|----------|----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | ANDC     | #xx:8, EXR | 0 : 1              | 4 : 1    | 0 : 6    | IMM      | 2             |

## Notes

## 2.2.6 BAND

## BAND (Bit AND)

## Bit Logical AND

## Operation

$$C \wedge (\text{<bit No.> of <EAd>) \rightarrow C$$

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | — | — | — | ↕ |

## Assembly-Language Format

$$\text{BAND } \#xx:3, \text{<EAd>}$$

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

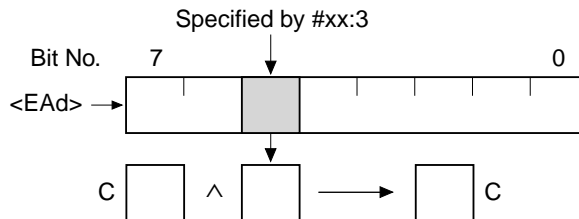
C: Stores the result of the operation.

## Operand Size

Byte

## Description

This instruction ANDs a specified bit in the destination operand with the carry flag and stores the result in the carry flag. The bit number is specified by 3-bit immediate data. The destination operand contents remain unchanged.



## Available Registers

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

## BAND (Bit AND)

## Bit Logical AND

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |  |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|--|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |  |   |
| Register direct   | BAND     | #xx:3, Rd     | 7                  | 6        | 0:IMM    | rd       |          |          |          |          |               |  | 1 |
| Register indirect | BAND     | #xx:3, @ERd   | 7                  | C        | 0:erd    | 0        | 7        | 6        | 0:IMM    | 0        |               |  | 3 |
| Absolute address  | BAND     | #xx:3, @aa:8  | 7                  | E        | abs      | 7        | 6        | 0:IMM    | 0        |          |               |  | 3 |
| Absolute address  | BAND     | #xx:3, @aa:16 | 6                  | A        | 1        | 0        | abs      | 7        | 6        | 0:IMM    | 0             |  | 4 |
| Absolute address  | BAND     | #xx:3, @aa:32 | 6                  | A        | 3        | 0        | abs      | 7        | 6        | 0:IMM    | 0             |  | 5 |

Note: \* The addressing mode is the addressing mode of the destination operand <ERd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.7 Bcc

**Bcc (Branch conditionally)****Conditional Branch****Operation**

If condition is true, then

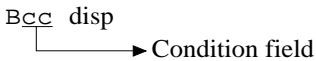
PC + disp → PC

else next;

**Condition Code**

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

**Assembly-Language Format**

Bcc disp  


H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Operand Size**

—

**Description**

If the condition specified in the condition field (cc) is true, a displacement is added to the program counter (PC) and execution branches to the resulting address. If the condition is false, the next instruction is executed. The PC value used in the address calculation is the starting address of the instruction immediately following the Bcc instruction. The displacement is a signed 8-bit or 16-bit value. The branch destination address can be located in the range from -126 to +128 bytes or -32766 to +32768 bytes from the Bcc instruction.

| Mnemonic  | Meaning                    | cc   | Condition   | Signed/Unsigned*           |
|-----------|----------------------------|------|-------------|----------------------------|
| BRA (BT)  | Always (true)              | 0000 | True        |                            |
| BRN (BF)  | Never (false)              | 0001 | False       |                            |
| BHI       | High                       | 0010 | CvZ = 0     | X > Y (unsigned)           |
| BLS       | Low or Same                | 0011 | CvZ = 1     | X ≤ Y (unsigned)           |
| BCC (BHS) | Carry Clear (High or Same) | 0100 | C = 0       | X ≥ Y (unsigned)           |
| BCS (BLO) | Carry Set (Low)            | 0101 | C = 1       | X < Y (unsigned)           |
| BNE       | Not Equal                  | 0110 | Z = 0       | X ≠ Y (unsigned or signed) |
| BEQ       | Equal                      | 0111 | Z = 1       | X = Y (unsigned or signed) |
| BVC       | oVerflow Clear             | 1000 | V = 0       |                            |
| BVS       | oVerflow Set               | 1001 | V = 1       |                            |
| BPL       | PLus                       | 1010 | N = 0       |                            |
| BMI       | MInus                      | 1011 | N = 1       |                            |
| BGE       | Greater or Equal           | 1100 | N⊕V = 0     | X ≥ Y (signed)             |
| BLT       | Less Than                  | 1101 | N⊕V = 1     | X < Y (signed)             |
| BGT       | Greater Than               | 1110 | Zv(N⊕V) = 0 | X > Y (signed)             |
| BLE       | Less or Equal              | 1111 | Zv(N⊕V) = 1 | X ≤ Y (signed)             |

Note: \* If the immediately preceding instruction is a CMP instruction, X is the general register contents (destination operand) and Y is the source operand.

**Bcc (Branch conditionally)****Conditional Branch****Operand Format and Number of States Required for Execution**

| Addressing Mode          | Mnemonic  | Operands | Instruction Format |          |          |          | No. of States |
|--------------------------|-----------|----------|--------------------|----------|----------|----------|---------------|
|                          |           |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Program-counter relative | BRA (BT)  | d:8      | 4                  | 0        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | 0        | 0        | disp          |
| Program-counter relative | BRN (BF)  | d:8      | 4                  | 1        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | 1        | 0        | disp          |
| Program-counter relative | BHI       | d:8      | 4                  | 2        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | 2        | 0        | disp          |
| Program-counter relative | BLS       | d:8      | 4                  | 3        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | 3        | 0        | disp          |
| Program-counter relative | Bcc (BHS) | d:8      | 4                  | 4        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | 4        | 0        | disp          |
| Program-counter relative | BCS (BLO) | d:8      | 4                  | 5        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | 5        | 0        | disp          |
| Program-counter relative | BNE       | d:8      | 4                  | 6        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | 6        | 0        | disp          |
| Program-counter relative | BEQ       | d:8      | 4                  | 7        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | 7        | 0        | disp          |
| Program-counter relative | BVC       | d:8      | 4                  | 8        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | 8        | 0        | disp          |
| Program-counter relative | BVS       | d:8      | 4                  | 9        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | 9        | 0        | disp          |
| Program-counter relative | BPL       | d:8      | 4                  | A        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | A        | 0        | disp          |
| Program-counter relative | BMI       | d:8      | 4                  | B        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | B        | 0        | disp          |
| Program-counter relative | BGE       | d:8      | 4                  | C        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | C        | 0        | disp          |
| Program-counter relative | BLT       | d:8      | 4                  | D        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | D        | 0        | disp          |
| Program-counter relative | BGT       | d:8      | 4                  | E        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | E        | 0        | disp          |
| Program-counter relative | BLE       | d:8      | 4                  | F        | disp     |          | 2             |
|                          |           | d:16     | 5                  | 8        | F        | 0        | disp          |

**Notes**

1. The branch destination address must be even.
2. In machine language BRA, BRN, BCC, and BCS are identical to BT, BF, BHS, and BLO, respectively.

## 2.2.8 BCLR

## BCLR (Bit CLear)

Bit Clear

## Operation

0 → (&lt;bit No.&gt; of &lt;EAd&gt;)

## Condition Code

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

## Assembly-Language Format

BCLR #xx:3, &lt;EAd&gt;

BCLR Rn, &lt;EAd&gt;

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

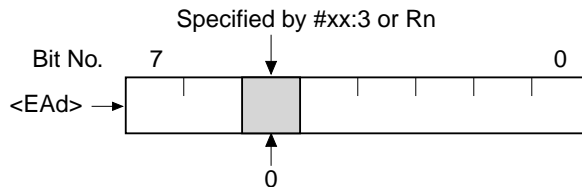
C: Previous value remains unchanged.

## Operand Size

Byte

## Description

This instruction clears a specified bit in the destination operand to 0. The bit number can be specified by 3-bit immediate data, or by the lower three bits of an 8-bit register Rn. The specified bit is not tested. The condition-code flags are not altered.



## Available Registers

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

Rn: R0L to R7L, R0H to R7H

## BCLR (Bit CLear)

Bit Clear

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |   |
| Register direct   | BCLR     | #xx:3, Rd     | 7 2                | 0:IMM rd |          |          |          |          |          |          |               | 1 |
| Register indirect | BCLR     | #xx:3, @ERd   | 7 D                | 0:erd 0  | 7 2      | 0:IMM 0  |          |          |          |          |               | 4 |
| Absolute address  | BCLR     | #xx:3, @aa:8  | 7 F                | abs      | 7 2      | 0:IMM 0  |          |          |          |          |               | 4 |
| Absolute address  | BCLR     | #xx:3, @aa:16 | 6 A                | 1 8      | abs      | 7 2      | 0:IMM 0  |          |          |          |               | 5 |
| Absolute address  | BCLR     | #xx:3, @aa:32 | 6 A                | 3 8      | abs      | 7 2      | 0:IMM 0  |          |          |          |               | 6 |
| Register direct   | BCLR     | Rn, Rd        | 6 2                | m rd     |          |          |          |          |          |          |               | 1 |
| Register indirect | BCLR     | Rn, @ERd      | 7 D                | 0:erd 0  | 6 2      | m 0      |          |          |          |          |               | 4 |
| Absolute address  | BCLR     | Rn, @aa:8     | 7 F                | abs      | 6 2      | m 0      |          |          |          |          |               | 4 |
| Absolute address  | BCLR     | Rn, @aa:16    | 6 A                | 1 8      | abs      | 6 2      | m 0      |          |          |          |               | 5 |
| Absolute address  | BCLR     | Rn, @aa:32    | 6 A                | 3 8      | abs      | 6 2      | m 0      |          |          |          |               | 6 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAAd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.9 BIAND

## BIAND (Bit Invert AND)

## Bit Logical AND

## Operation

$$C \wedge [\neg (\text{<bit No.> of <EAd>})] \rightarrow C$$

## Condition Code

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | — | — | — | ↕ |

## Assembly-Language Format

`BIAND #xx:3, <EAd>`

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

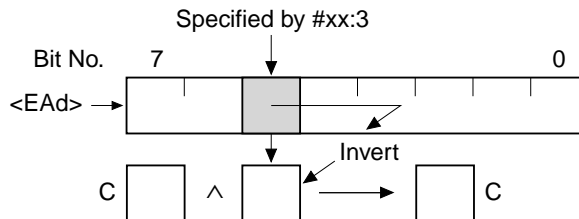
C: Stores the result of the operation.

## Operand Size

Byte

## Description

This instruction ANDs the inverse of a specified bit in the destination operand with the carry flag and stores the result in the carry flag. The bit number is specified by 3-bit immediate data. The destination operand contents remain unchanged.



## Available Registers

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7



## BIAND (Bit Invert AND)

## Bit Logical AND

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |           |          |          |          |          |          |          | No. of States |   |
|-------------------|----------|---------------|--------------------|-----------|----------|----------|----------|----------|----------|----------|---------------|---|
|                   |          |               | 1st byte           | 2nd byte  | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |   |
| Register direct   | BIAND    | #xx:3, Rd     | 7 6                | 1:IMM: rd |          |          |          |          |          |          |               | 1 |
| Register indirect | BIAND    | #xx:3, @ERd   | 7 C                | 0:erd     | 7 6      | 1:IMM: 0 |          |          |          |          |               | 3 |
| Absolute address  | BIAND    | #xx:3, @aa:8  | 7 E                | abs       | 7 6      | 1:IMM: 0 |          |          |          |          |               | 3 |
| Absolute address  | BIAND    | #xx:3, @aa:16 | 6 A                | 1 0       | abs      |          | 7 6      | 1:IMM: 0 |          |          |               | 4 |
| Absolute address  | BIAND    | #xx:3, @aa:32 | 6 A                | 3 0       | abs      |          | 7 6      | 1:IMM: 0 |          |          |               | 5 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.10 BILD

**BILD (Bit Invert Load)****Bit Load****Operation** $\neg$  (<bit No.> of <EAd>)  $\rightarrow$  C**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | — | — | — | ↕ |

**Assembly-Language Format**

BILD #xx:3, &lt;EAd&gt;

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

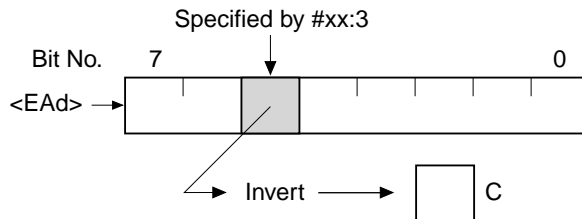
C: Loaded with the inverse of the specified bit.

**Operand Size**

Byte

**Description**

This instruction loads the inverse of a specified bit from the destination operand into the carry flag. The bit number is specified by 3-bit immediate data. The destination operand contents remain unchanged.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

## BILD (Bit Invert Load)

## Bit Load

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |  |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|--|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |  |   |
| Register direct   | BILD     | #xx:3, Rd     | 7                  | 7        | rd       |          |          |          |          |          |               |  | 1 |
| Register indirect | BILD     | #xx:3, @ERd   | 7                  | C        | 0        | erd      | 0        | 1:IMM    | 0        |          |               |  | 3 |
| Absolute address  | BILD     | #xx:3, @aa:8  | 7                  | E        | abs      | 7        | 7        | 1:IMM    | 0        |          |               |  | 3 |
| Absolute address  | BILD     | #xx:3, @aa:16 | 6                  | A        | 1        | 0        | abs      | 7        | 7        | 1:IMM    | 0             |  | 4 |
| Absolute address  | BILD     | #xx:3, @aa:32 | 6                  | A        | 3        | 0        | abs      | 7        | 7        | 1:IMM    | 0             |  | 5 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.11 BIOR

## BIOR (Bit Invert inclusive OR)

## Bit Logical OR

## Operation

$$C \vee [\neg (\text{<bit No.> of <EAd>)] \rightarrow C$$

## Condition Code

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | — | — | — | ↕ |

## Assembly-Language Format

$$\text{BIOR } \#xx:3, \text{<EAd>}$$

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

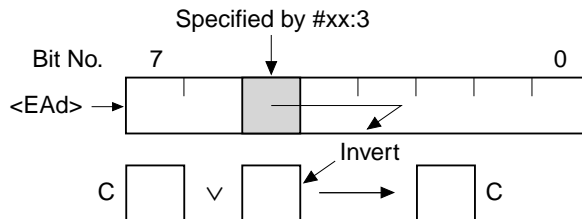
C: Stores the result of the operation.

## Operand Size

Byte

## Description

This instruction ORs the inverse of a specified bit in the destination operand with the carry flag and stores the result in the carry flag. The bit number is specified by 3-bit immediate data. The destination operand contents remain unchanged.



## Available Registers

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

## BIOR (Bit Invert inclusive OR)

## Bit Logical OR

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |   |
| Register direct   | BIOR     | #xx:3, Rd     | 7 4                | 1:IMM rd |          |          |          |          |          |          |               | 1 |
| Register indirect | BIOR     | #xx:3, @ERd   | 7 C                | 0:erd 0  | 7 4      | 1:IMM 0  |          |          |          |          |               | 3 |
| Absolute address  | BIOR     | #xx:3, @aa:8  | 7 E                | abs      | 7 4      | 1:IMM 0  |          |          |          |          |               | 3 |
| Absolute address  | BIOR     | #xx:3, @aa:16 | 6 A                | 1 0      |          | abs      |          | 7 4      | 1:IMM 0  |          |               | 4 |
| Absolute address  | BIOR     | #xx:3, @aa:32 | 6 A                | 3 0      |          |          |          | abs      |          | 7 4      | 1:IMM 0       | 5 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.12 BIST

**BIST (Bit Invert STore)****Bit Store****Operation**
 $\neg C \rightarrow (\text{<bit No.> of <EAd>})$ 
**Condition Code**

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

**Assembly-Language Format**

BIST #xx:3, &lt;EAd&gt;

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

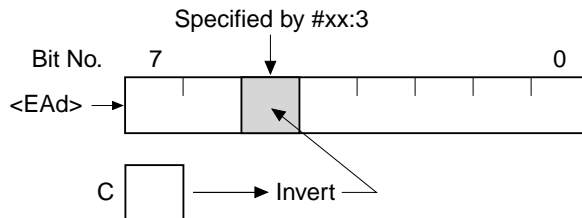
C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction stores the inverse of the carry flag in a specified bit location in the destination operand. The bit number is specified by 3-bit immediate data. Other bits in the destination operand remain unchanged.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

## BIST (Bit Invert STore)

## Bit Store

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |           |          |          |          |          |          | No. of States |  |   |
|-------------------|----------|---------------|--------------------|----------|-----------|----------|----------|----------|----------|----------|---------------|--|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte  | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |  |   |
| Register direct   | BIST     | #xx:3, Rd     | 6                  | 7        | 1:IMM; rd |          |          |          |          |          |               |  | 1 |
| Register indirect | BIST     | #xx:3, @ERd   | 7                  | D        | 0:erd; 0  | 6        | 7        | 1:IMM; 0 |          |          |               |  | 4 |
| Absolute address  | BIST     | #xx:3, @aa:8  | 7                  | F        | abs       | 6        | 7        | 1:IMM; 0 |          |          |               |  | 4 |
| Absolute address  | BIST     | #xx:3, @aa:16 | 6                  | A        | 1         | 8        | abs      |          | 6        | 7        | 1:IMM; 0      |  | 5 |
| Absolute address  | BIST     | #xx:3, @aa:32 | 6                  | A        | 3         | 8        | abs      |          | 6        | 7        | 1:IMM; 0      |  | 6 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.13 BIXOR

**BIXOR (Bit Invert eXclusive OR)****Bit Exclusive Logical OR****Operation**

$$C \oplus [\neg (\text{<bit No.> of <EAd>})] \rightarrow C$$
**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | — | — | — | ↕ |

**Assembly-Language Format**
`BIXOR #xx:3, <EAd>`

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

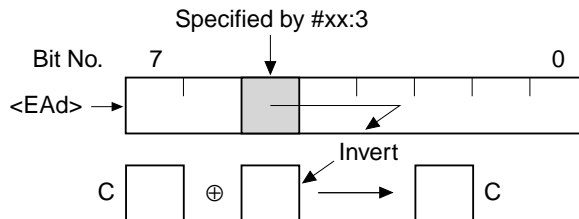
C: Stores the result of the operation.

**Operand Size**

Byte

**Description**

This instruction exclusively ORs the inverse of a specified bit in the destination operand with the carry flag and stores the result in the carry flag. The bit number is specified by 3-bit immediate data. The destination operand contents remain unchanged.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7



## BIXOR (Bit Invert eXclusive OR)

## Bit Exclusive Logical OR

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |   |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|---|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |   |   |
| Register direct   | BIXOR    | #xx:3, Rd     | 7                  | 5        | 1:IMM    | rd       |          |          |          |          |               |   | 1 |
| Register indirect | BIXOR    | #xx:3, @ERd   | 7                  | C        | 0:erd    | 0        | 1:IMM    | 0        |          |          |               |   | 3 |
| Absolute address  | BIXOR    | #xx:3, @aa:8  | 7                  | E        | abs      | 7        | 5        | 1:IMM    | 0        |          |               |   | 3 |
| Absolute address  | BIXOR    | #xx:3, @aa:16 | 6                  | A        | 1        | 0        | abs      |          | 7        | 5        | 1:IMM         | 0 | 4 |
| Absolute address  | BIXOR    | #xx:3, @aa:32 | 6                  | A        | 3        | 0        | abs      |          | 7        | 5        | 1:IMM         | 0 | 5 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

### Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.14 BLD

## BLD (Bit Load)

Bit Load

## Operation

(&lt;Bit No.&gt; of &lt;EAd&gt;) → C

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | — | — | — | ↕ |

## Assembly-Language Format

BLD #xx:3, &lt;EAd&gt;

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

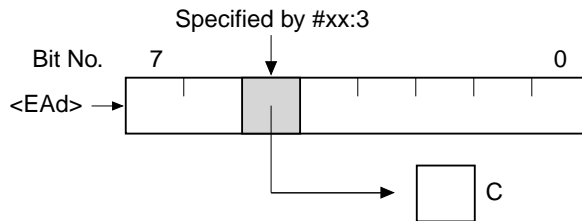
C: Loaded from the specified bit.

## Operand Size

Byte

## Description

This instruction loads a specified bit from the destination operand into the carry flag. The bit number is specified by 3-bit immediate data. The destination operand contents remain unchanged.



## Available Registers

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

## BLD (Bit Load)

## Bit Load

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |   |
| Register direct   | BLD      | #xx:3, Rd     | 7                  | 0:IMM:rd |          |          |          |          |          |          |               | 1 |
| Register indirect | BLD      | #xx:3, @ERd   | 7                  | 0:erd    | 7        | 7        | 0:IMM:0  |          |          |          |               | 3 |
| Absolute address  | BLD      | #xx:3, @aa:8  | 7                  | E        | 7        | 7        | 0:IMM:0  |          |          |          |               | 3 |
| Absolute address  | BLD      | #xx:3, @aa:16 | 6                  | A        | 1        | 0        | abs      | 7        | 7        | 0:IMM:0  |               | 4 |
| Absolute address  | BLD      | #xx:3, @aa:32 | 6                  | A        | 3        | 0        | abs      | 7        | 7        | 0:IMM:0  |               | 5 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.15 BNOT

**BNOT (Bit NOT)****Bit NOT****Operation**

$\neg$  (<bit No.> of <EAd>)  $\rightarrow$  (bit No. of <EAd>)

**Condition Code**

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

**Assembly-Language Format**

BNOT #xx:3, <EAd>

BNOT Rn, <EAd>

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

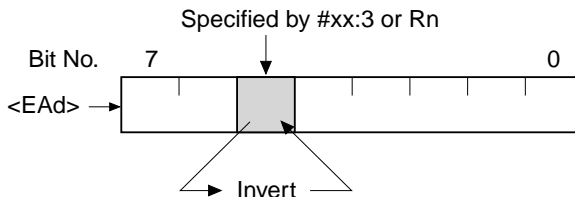
C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction inverts a specified bit in the destination operand. The bit number is specified by 3-bit immediate data or by the lower 3 bits of an 8-bit register Rn. The specified bit is not tested. The condition code remains unchanged.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

Rn: R0L to R7L, R0H to R7H

## BNOT (Bit NOT)

## Bit NOT

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |   |
| Register direct   | BNOT     | #xx:3, Rd     | 7 1                | 0:IMM rd |          |          |          |          |          |          |               | 1 |
| Register indirect | BNOT     | #xx:3, @ERd   | 7 D                | 0:erd 0  | 7 1      | 0:IMM 0  |          |          |          |          |               | 4 |
| Absolute address  | BNOT     | #xx:3, @aa:8  | 7 F                | abs      | 7 1      | 0:IMM 0  |          |          |          |          |               | 4 |
| Absolute address  | BNOT     | #xx:3, @aa:16 | 6 A                | 1 8      | abs      |          | 7 1      | 0:IMM 0  |          |          |               | 5 |
| Absolute address  | BNOT     | #xx:3, @aa:32 | 6 A                | 3 8      | abs      |          |          |          | 7 1      | 0:IMM 0  |               | 6 |
| Register direct   | BNOT     | Rn, Rd        | 6 1                | rn rd    |          |          |          |          |          |          |               | 1 |
| Register indirect | BNOT     | Rn, @ERd      | 7 D                | 0:erd 0  | 6 1      | rn 0     |          |          |          |          |               | 4 |
| Absolute address  | BNOT     | Rn, @aa:8     | 7 F                | abs      | 6 1      | rn 0     |          |          |          |          |               | 4 |
| Absolute address  | BNOT     | Rn, @aa:16    | 6 A                | 1 8      | abs      |          | 6 1      | rn 0     |          |          |               | 5 |
| Absolute address  | BNOT     | Rn, @aa:32    | 6 A                | 3 8      | abs      |          |          |          | 6 1      | rn 0     |               | 6 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.16 BOR

## BOR (Bit inclusive OR)

## Bit Logical OR

## Operation

$$C \vee (\text{<bit No.> of <EAd>) \rightarrow C$$

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | — | — | — | ↕ |

## Assembly-Language Format

BOR #xx:3, &lt;EAd&gt;

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

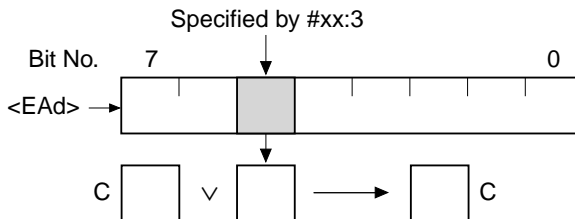
C: Stores the result of the operation.

## Operand Size

Byte

## Description

This instruction ORs a specified bit in the destination operand with the carry flag and stores the result in the carry flag. The bit number is specified by 3-bit immediate data. The destination operand contents remain unchanged.



## Available Registers

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

## BOR (Bit inclusive OR)

## Bit Logical OR

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |  |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|--|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |  |   |
| Register direct   | BOR      | #xx:3, Rd     | 7                  | 4        | 0:IMM    | rd       |          |          |          |          |               |  | 1 |
| Register indirect | BOR      | #xx:3, @ERd   | 7                  | C        | 0:erd    | 0        | 7        | 4        | 0:IMM    | 0        |               |  | 3 |
| Absolute address  | BOR      | #xx:3, @aa:8  | 7                  | E        | abs      | 7        | 4        | 0:IMM    | 0        |          |               |  | 3 |
| Absolute address  | BOR      | #xx:3, @aa:16 | 6                  | A        | 1        | 0        | abs      | 7        | 4        | 0:IMM    | 0             |  | 4 |
| Absolute address  | BOR      | #xx:3, @aa:32 | 6                  | A        | 3        | 0        | abs      | 7        | 4        | 0:IMM    | 0             |  | 5 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.17 BSET

**BSET (Bit SET)****Bit Set****Operation**

1 → (&lt;bit No.&gt; of &lt;EAd&gt;)

**Condition Code**

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

**Assembly-Language Format**

BSET #xx:3, &lt;EAd&gt;

BSET Rn, &lt;EAd&gt;

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

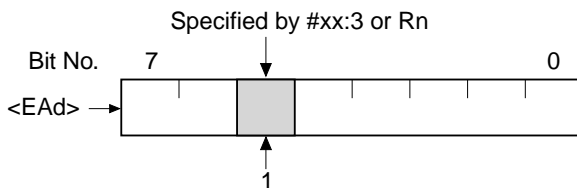
C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction sets a specified bit in the destination operand to 1. The bit number can be specified by 3-bit immediate data, or by the lower three bits of an 8-bit register Rn. The specified bit is not tested. The condition code flags are not altered.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

Rn: R0L to R7L, R0H to R7H



## BSET (Bit SET)

## Bit Set

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |   |
| Register direct   | BSET     | #xx:3, Rd     | 7 0                | 0:IMM rd |          |          |          |          |          |          |               | 1 |
| Register indirect | BSET     | #xx:3, @ERd   | 7 D                | 0:erd 0  | 7 0      | 0:IMM 0  |          |          |          |          |               | 4 |
| Absolute address  | BSET     | #xx:3, @aa:8  | 7 F                | abs      | 7 0      | 0:IMM 0  |          |          |          |          |               | 4 |
| Absolute address  | BSET     | #xx:3, @aa:16 | 6 A                | 1 8      | abs      |          | 7 0      | 0:IMM 0  |          |          |               | 5 |
| Absolute address  | BSET     | #xx:3, @aa:32 | 6 A                | 3 8      |          | abs      |          |          | 7 0      | 0:IMM 0  |               | 6 |
| Register direct   | BSET     | Rn, Rd        | 6 0                | rn rd    |          |          |          |          |          |          |               | 1 |
| Register indirect | BSET     | Rn, @ERd      | 7 D                | 0:erd 0  | 6 0      | rn 0     |          |          |          |          |               | 4 |
| Absolute address  | BSET     | Rn, @aa:8     | 7 F                | abs      | 6 0      | rn 0     |          |          |          |          |               | 4 |
| Absolute address  | BSET     | Rn, @aa:16    | 6 A                | 1 8      |          | abs      | 6 0      | rn 0     |          |          |               | 5 |
| Absolute address  | BSET     | Rn, @aa:32    | 6 A                | 3 8      |          |          | abs      |          | 6 0      | rn 0     |               | 6 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.18 BSR

## BSR (Branch to SubRoutine)

## Branch to Subroutine

## Operation

PC → @-SP

PC + disp → PC

## Condition Code

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

## Assembly-Language Format

BSR disp

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

## Operand Size

—

## Description

This instruction branches to a subroutine at a specified address. It pushes the program counter (PC) value onto the stack as a restart address, then adds a specified displacement to the PC value and branches to the resulting address. The PC value pushed onto the stack is the address of the instruction following the BSR instruction. The displacement is a signed 8-bit or 16-bit value, so the possible branching range is -126 to +128 bytes or -32766 to +32768 bytes from the address of the BSR instruction.

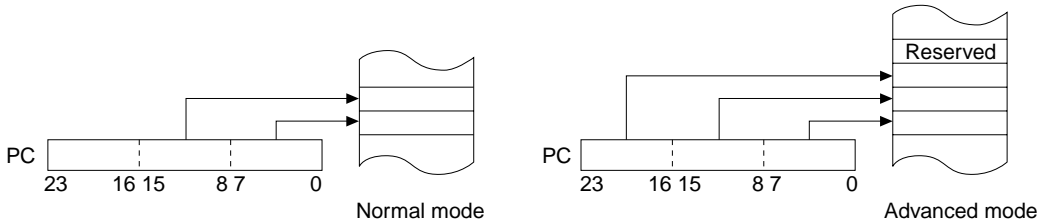
## Operand Format and Number of States Required for Execution

| Addressing Mode          | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |          |   |
|--------------------------|----------|----------|--------------------|----------|----------|----------|---------------|----------|---|
|                          |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte | Normal        | Advanced |   |
| Program-counter relative | BSR      | d:8      | 5                  | 5        | disp     |          |               | 3        | 4 |
|                          |          | d:16     | 5                  | C        | 0        | 0        | disp          | 4        | 5 |

**BSR (Branch to SubRoutine)****Branch to Subroutine****Notes**

The stack structure differs between normal mode and advanced mode. In normal mode only the lower 16 bits of the program counter are pushed onto the stack.

Ensure that the branch destination address is even.



## 2.2.19 BST

## BST (Bit Store)

Bit Store

## Operation

C → (&lt;bit No.&gt; of &lt;EAd&gt;)

## Condition Code

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

## Assembly-Language Format

BST #xx:3, &lt;EAd&gt;

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

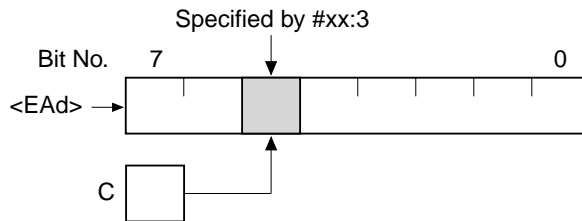
C: Previous value remains unchanged.

## Operand Size

Byte

## Description

This instruction stores the carry flag in a specified bit location in the destination operand. The bit number is specified by 3-bit immediate data.



## Available Registers

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

## BST (Bit Store)

## Bit Store

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |   |
| Register direct   | BST      | #xx:3, Rd     | 6 7                | 0:IMM rd |          |          |          |          |          |          |               | 1 |
| Register indirect | BST      | #xx:3, @ERd   | 7 D                | 0:erd 0  | 6 7      | 0:IMM 0  |          |          |          |          |               | 4 |
| Absolute address  | BST      | #xx:3, @aa:8  | 7 F                | abs      | 6 7      | 0:IMM 0  |          |          |          |          |               | 4 |
| Absolute address  | BST      | #xx:3, @aa:16 | 6 A                | 1 8      | abs      |          | 6 7      | 0:IMM 0  |          |          |               | 5 |
| Absolute address  | BST      | #xx:3, @aa:32 | 6 A                | 3 8      | abs      |          | 6 7      | 0:IMM 0  |          |          |               | 6 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.20 BTST

## BTST (Bit TeST)

Bit Test

## Operation

 $\neg$  (<Bit No.> of <EAd>)  $\rightarrow$  Z

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | — | ↕ | — | — |

## Assembly-Language Format

BTST #xx:3, &lt;EAd&gt;

BTST Rn, &lt;EAd&gt;

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Set to 1 if the specified bit is zero; otherwise cleared to 0.

V: Previous value remains unchanged.

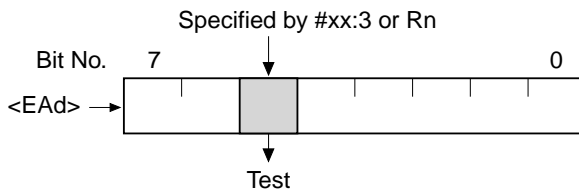
C: Previous value remains unchanged.

## Operand Size

Byte

## Description

This instruction tests a specified bit in the destination operand and sets or clears the zero flag according to the result. The bit number can be specified by 3-bit immediate data, or by the lower three bits of an 8-bit register Rn. The destination operand contents remain unchanged.



## Available Registers

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

Rn: R0L to R7L, R0H to R7H

## BTST (Bit TeST)

## Bit Test

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |   |   |       |   |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|---|---|-------|---|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |   |   |       |   |   |
| Register direct   | BTST     | #xx:3, Rd     | 7                  | 3        | 0:IMM    | rd       |          |          |          |          |               |   | 1 |       |   |   |
| Register indirect | BTST     | #xx:3, @ERd   | 7                  | C        | 0:erd    | 0        | 7        | 3        | 0:IMM    | 0        |               |   | 3 |       |   |   |
| Absolute address  | BTST     | #xx:3, @aa:8  | 7                  | E        | abs      | 7        | 3        | 0:IMM    | 0        |          |               |   | 3 |       |   |   |
| Absolute address  | BTST     | #xx:3, @aa:16 | 6                  | A        | 1        | 0        | abs      | 7        | 3        | 0:IMM    | 0             |   | 4 |       |   |   |
| Absolute address  | BTST     | #xx:3, @aa:32 | 6                  | A        | 3        | 0        | abs      |          |          |          |               | 7 | 3 | 0:IMM | 0 | 5 |
| Register direct   | BTST     | Rn, Rd        | 6                  | 3        | rn       | rd       |          |          |          |          |               |   |   |       |   | 1 |
| Register indirect | BTST     | Rn, @ERd      | 7                  | C        | 0:erd    | 0        | 6        | 3        | rn       | 0        |               |   |   |       |   | 3 |
| Absolute address  | BTST     | Rn, @aa:8     | 7                  | E        | abs      | 6        | 3        | rn       | 0        |          |               |   |   |       |   | 3 |
| Absolute address  | BTST     | Rn, @aa:16    | 6                  | A        | 1        | 0        | abs      | 6        | 3        | rn       | 0             |   |   |       |   | 4 |
| Absolute address  | BTST     | Rn, @aa:32    | 6                  | A        | 3        | 0        | abs      |          |          |          |               | 6 | 3 | rn    | 0 | 5 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

## Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.21 BXOR

## BXOR (Bit eXclusive OR)

## Bit Exclusive Logical OR

## Operation

$$C \oplus (\text{<bit No.> of <EAd>}) \rightarrow C$$

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | — | — | — | ↕ |

## Assembly-Language Format

$$\text{BXOR } \#xx:3, \text{<EAd>}$$

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

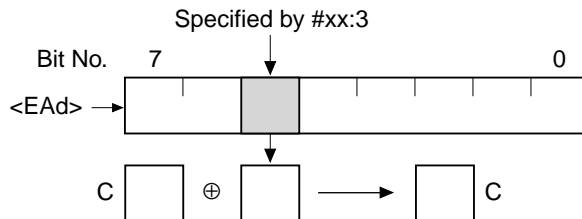
C: Stores the result of the operation.

## Operand Size

Byte

## Description

This instruction exclusively ORs a specified bit in the destination operand with the carry flag and stores the result in the carry flag. The bit number is specified by 3-bit immediate data. The destination operand contents remain unchanged.



## Available Registers

Rd: R0L to R7L, R0H to R7H

ERd: ER0 to ER7



## BXOR (Bit eXclusive OR)

## Bit Exclusive Logical OR

## Operand Format and Number of States Required for Execution

| Addressing Mode*  | Mnemonic | Operands      | Instruction Format |          |          |          |          |          |          |          | No. of States |  |   |
|-------------------|----------|---------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|--|---|
|                   |          |               | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |  |   |
| Register direct   | BXOR     | #xx:3, Rd     | 7                  | 5        | 0:IMM    | rd       |          |          |          |          |               |  | 1 |
| Register indirect | BXOR     | #xx:3, @ERd   | 7                  | C        | 0:erd    | 0        | 7        | 5        | 0:IMM    | 0        |               |  | 3 |
| Absolute address  | BXOR     | #xx:3, @aa:8  | 7                  | E        | abs      | 7        | 5        | 0:IMM    | 0        |          |               |  | 3 |
| Absolute address  | BXOR     | #xx:3, @aa:16 | 6                  | A        | 1        | 0        | abs      | 7        | 5        | 0:IMM    | 0             |  | 4 |
| Absolute address  | BXOR     | #xx:3, @aa:32 | 6                  | A        | 3        | 0        | abs      | 7        | 5        | 0:IMM    | 0             |  | 5 |

Note: \* The addressing mode is the addressing mode of the destination operand <EAd>.

### Notes

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

## 2.2.22 CLRMAC

## CLRMAC (CLear MAC register)

## Initialize Multiply-Accumulate Register

## Operation

0 → MACH, MACL

## Condition Code

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

## Assembly-Language Format

CLRMAC

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

## Operand Size

—

## Description

This instruction simultaneously clears registers MACH and MACL.

It is supported only by the H8S/2600 CPU.

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |             |          |          | No. of States |
|-----------------|----------|----------|--------------------|-------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte    | 3rd byte | 4th byte |               |
| —               | CLRMAC   | —        | 0<br>⋮<br>1        | A<br>⋮<br>0 |          |          | 2*            |

Note: \* A maximum of three additional states are required for execution of this instruction within three states after execution of a MAC instruction. For example, if there is a one-state instruction (such as NOP) between the MAC instruction and this instruction, this instruction will be two states longer.

The number of states may differ depending on the product. For details, refer to the relevant microcontroller hardware manual of the product in question.

## Notes

Execution of this instruction also clears the overflow flag in the multiplier to 0.

**2.2.23 (1) CMP (B)****CMP (CoMPare)****Compare****Operation**

Rd – (EAs), set/clear CCR

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

CMP .B &lt;EAs&gt;, Rd

- H: Set to 1 if there is a borrow at bit 3; otherwise cleared to 0.
- N: Set to 1 if the result is negative; otherwise cleared to 0.
- Z: Set to 1 if the result is zero; otherwise cleared to 0.
- V: Set to 1 if an overflow occurs; otherwise cleared to 0.
- C: Set to 1 if there is a borrow at bit 7; otherwise cleared to 0.

**Operand Size**

Byte

**Description**

This instruction subtracts the source operand from the contents of an 8-bit register Rd (destination operand) and sets or clears the condition code bits according to the result. The contents of the 8-bit register Rd remain unchanged.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

Rs: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands  | Instruction Format |               |          |          | No. of States |
|-----------------|----------|-----------|--------------------|---------------|----------|----------|---------------|
|                 |          |           | 1st byte           | 2nd byte      | 3rd byte | 4th byte |               |
| Immediate       | CMP.B    | #xx:8, Rd | A<br>⋮<br>rd       | IMM           |          |          | 1             |
| Register direct | CMP.B    | Rs, Rd    | 1<br>⋮<br>C        | rs<br>⋮<br>rd |          |          | 1             |

**Notes**

## 2.2.23 (2) CMP (W)

## CMP (CoMPare)

Compare

## Operation

Rd – (EAs), set/clear CCR

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

## Assembly-Language Format

CMP .W &lt;EAs&gt;, Rd

## Operand Size

Word

H: Set to 1 if there is a borrow at bit 11; otherwise cleared to 0.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Set to 1 if there is a borrow at bit 15; otherwise cleared to 0.

## Description

This instruction subtracts the source operand from the contents of a 16-bit register Rd (destination operand) and sets or clears the condition code bits according to the result. The contents of the 16-bit register Rd remain unchanged.

## Available Registers

Rd: R0 to R7, E0 to E7

Rs: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands   | Instruction Format |          |          |          | No. of States |
|-----------------|----------|------------|--------------------|----------|----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | CMP.W    | #xx:16, Rd | 7   9              | 2   rd   | IMM      |          | 2             |
| Register direct | CMP.W    | Rs, Rd     | 1   D              | rs   rd  |          |          | 1             |

## Notes

**2.2.23 (3) CMP (L)****CMP (CoMPare)****Compare****Operation**

ERd – (EAs), set/clear CCR

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

CMP .L &lt;EAs&gt;, ERd

- H: Set to 1 if there is a borrow at bit 27; otherwise cleared to 0.
- N: Set to 1 if the result is negative; otherwise cleared to 0.
- Z: Set to 1 if the result is zero; otherwise cleared to 0.
- V: Set to 1 if an overflow occurs; otherwise cleared to 0.
- C: Set to 1 if there is a borrow at bit 31; otherwise cleared to 0.

**Operand Size**

Longword

**Description**

This instruction subtracts the source operand from the contents of a 32-bit register ERd (destination operand) and sets or clears the condition code bits according to the result. The contents of the 32-bit register ERd remain unchanged.

**Available Registers**

ERd: ER0 to ER7

ERs: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands    | Instruction Format |   |          |     |          |          | No. of States |          |          |   |
|-----------------|----------|-------------|--------------------|---|----------|-----|----------|----------|---------------|----------|----------|---|
|                 |          |             | 1st byte           |   | 2nd byte |     | 3rd byte | 4th byte |               | 5th byte | 6th byte |   |
| Immediate       | CMP.L    | #xx:32, ERd | 7                  | A | 2        | 0   | erd      | IMM      |               |          | 3        |   |
| Register direct | CMP.L    | ERs, ERd    | 1                  | F | 1        | ers | 0        | erd      |               |          |          | 1 |

**Notes**

## 2.2.24 DAA

**DAA (Decimal Adjust Add)****Decimal Adjust****Operation**

Rd (decimal adjust) → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | * | — | ↕ | ↕ | * | ↕ |

**Assembly-Language Format**

DAA Rd

**Operand Size**

Byte

- H: Undetermined (no guaranteed value).  
 N: Set to 1 if the adjusted result is negative; otherwise cleared to 0.  
 Z: Set to 1 if the adjusted result is zero; otherwise cleared to 0.  
 V: Undetermined (no guaranteed value).  
 C: Set to 1 if there is a carry at bit 7; otherwise left unchanged.

**Description**

Given that the result of an addition operation performed by an ADD.B or ADDX instruction on 4-bit BCD data is contained in an 8-bit register Rd and the carry and half-carry flags, the DAA instruction adjusts the contents of the 8-bit register Rd (destination operand) by adding H'00, H'06, H'60, or H'66 according to the table below.

| C Flag before Adjustment | Upper 4 Bits before Adjustment | H Flag before Adjustment | Lower 4 Bits before Adjustment | Value Added (Hexadecimal) | C Flag after Adjustment |
|--------------------------|--------------------------------|--------------------------|--------------------------------|---------------------------|-------------------------|
| 0                        | 0 to 9                         | 0                        | 0 to 9                         | 00                        | 0                       |
| 0                        | 0 to 8                         | 0                        | A to F                         | 06                        | 0                       |
| 0                        | 0 to 9                         | 1                        | 0 to 3                         | 06                        | 0                       |
| 0                        | A to F                         | 0                        | 0 to 9                         | 60                        | 1                       |
| 0                        | 9 to F                         | 0                        | A to F                         | 66                        | 1                       |
| 0                        | A to F                         | 1                        | 0 to 3                         | 66                        | 1                       |
| 1                        | 0 to 2                         | 0                        | 0 to 9                         | 60                        | 1                       |
| 1                        | 0 to 2                         | 0                        | A to F                         | 66                        | 1                       |
| 1                        | 0 to 3                         | 1                        | 0 to 3                         | 66                        | 1                       |

**DAA (Decimal Adjust Add)****Decimal Adjust****Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | DAA      | Rd       | 0   F              | 0   rd   |          |          | 1             |

**Notes**

Valid results (8-bit register Rd contents and C, V, Z, N, and H flags) are not assured if this instruction is executed under conditions other than those described above.

## 2.2.25 DAS

**DAS (Decimal Adjust Subtract)****Decimal Adjust****Operation**

Rd (decimal adjust) → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | * | — | ↕ | ↕ | * | 0 |

**Assembly-Language Format**

DAS Rd

H: Undetermined (no guaranteed value).

N: Set to 1 if the adjusted result is negative; otherwise cleared to 0.

Z: Set to 1 if the adjusted result is zero; otherwise cleared to 0.

V: Undetermined (no guaranteed value).

C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

Given that the result of a subtraction operation performed by a SUB.B, SUBX.B, or NEG.B instruction on 4-bit BCD data is contained in an 8-bit register Rd and the carry and half-carry flags, the DAS instruction adjusts the contents of the 8-bit register Rd (destination operand) by adding H'00, H'FA, H'A0, or H'9A according to the table below.

| C Flag before Adjustment | Upper 4 Bits before Adjustment | H Flag before Adjustment | Lower 4 Bits before Adjustment | Value Added (Hexadecimal) | C Flag after Adjustment |
|--------------------------|--------------------------------|--------------------------|--------------------------------|---------------------------|-------------------------|
| 0                        | 0 to 9                         | 0                        | 0 to 9                         | 00                        | 0                       |
| 0                        | 0 to 8                         | 1                        | 6 to F                         | FA                        | 0                       |
| 1                        | 7 to F                         | 0                        | 0 to 9                         | A0                        | 1                       |
| 1                        | 6 to F                         | 1                        | 6 to F                         | 9A                        | 1                       |

**Available Registers**

Rd: R0L to R7L, R0H to R7H



**DAS (Decimal Adjust Subtract)****Decimal Adjust****Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | DAS      | Rd       | 1 : F              | 0 : rd   |          |          | 1             |

**Notes**

Valid results (8-bit register Rd contents and C, V, Z, N, and H flags) are not assured if this instruction is executed under conditions other than those described above.

**2.2.26 (1) DEC (B)****DEC (DECrement)****Decrement****Operation**

Rd – 1 → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | ↕ | — |

**Assembly-Language Format**

DEC .B Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction decrements an 8-bit register Rd (destination operand) and stores the result in the 8-bit register Rd.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | DEC.B    | Rd       | 1                  | A        | 0        | rd       | 1             |

**Notes**

An overflow is caused by the operation H'80 – 1 → H'7F.

**2.2.26 (2) DEC (W)****DEC (DECrement)****Decrement****Operation**

Rd – 1 → Rd

Rd – 2 → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | ↕ | — |

**Assembly-Language Format**

DEC.W #1, Rd

DEC.W #2, Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Word

**Description**

This instruction subtracts the immediate value 1 or 2 from the contents of a 16-bit register Rd (destination operand) and stores the result in the 16-bit register Rd.

**Available Registers**

Rd: R0 to R7, E0 to E7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | DEC.W    | #1, Rd   | 1   B              | 5   rd   |          |          | 1             |
| Register direct | DEC.W    | #2, Rd   | 1   B              | D   rd   |          |          | 1             |

**Notes**

An overflow is caused by the operations H'8000 – 1 → H'7FFF, H'8000 – 2 → H'7FFE, and H'8001 – 2 → H'7FFF.

**2.2.26 (3) DEC (L)****DEC (DECrement)****Decrement****Operation**

ERd – 1 → ERd

ERd – 2 → ERd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | ↕ | — |

**Assembly-Language Format**

DEC.L #1, ERd

DEC.L #2, ERd

**Operand Size**

Longword

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Previous value remains unchanged.

**Description**

This instruction subtracts the immediate value 1 or 2 from the contents of a 32-bit register ERd (destination operand) and stores the result in the 32-bit register ERd.

**Available Registers**

ERd: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | DEC.L    | #1, ERd  | 1                  | B        | 7        | 0 erd    | 1             |
| Register direct | DEC.L    | #2, ERd  | 1                  | B        | F        | 0 erd    | 1             |

**Notes**

An overflow is caused by the operations H'80000000 – 1 → H'7FFFFFFF, H'80000000 – 2 → H'7FFFFFFE, and H'80000001 – 2 → H'7FFFFFFF.

## 2.2.27 (1) DIVXS (B)

## DIVXS (DIVide eXtend as Signed)

Divide Signed

## Operation

Rd ÷ Rs → Rd

## Condition Code

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | — | — |

## Assembly-Language Format

DIVXS.B Rs, Rd

H: Previous value remains unchanged.

N: Set to 1 if the quotient is negative; otherwise cleared to 0.

Z: Set to 1 if the divisor is zero; otherwise cleared to 0.

V: Previous value remains unchanged.

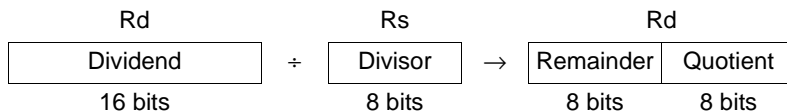
C: Previous value remains unchanged.

## Operand Size

Byte

## Description

This instruction divides the contents of a 16-bit register Rd (destination operand) by the contents of an 8-bit register Rs (source operand) and stores the result in the 16-bit register Rd. The division is signed. The operation performed is 16 bits ÷ 8 bits → 8-bit quotient and 8-bit remainder. The quotient is placed in the lower 8 bits of Rd. The remainder is placed in the upper 8 bits of Rd. The sign of the remainder matches the sign of the dividend.



Valid results are not assured if division by zero is attempted or an overflow occurs.

## Available Registers

Rd: R0 to R7, E0 to E7

Rs: R0L to R7L, R0H to R7H

**DIVXS (DIVide eXtend as Signed)****Divide Signed****Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |           |           |             | No. of States |
|-----------------|----------|----------|--------------------|-----------|-----------|-------------|---------------|
|                 |          |          | 1st byte           | 2nd byte  | 3rd byte  | 4th byte    |               |
| Register direct | DIVXS.B  | Rs, Rd   | 0 ..... 1          | D ..... 0 | 5 ..... 1 | rs ..... rd | 13            |

**Notes**

The N flag is set to 1 if the dividend and divisor have different signs, and cleared to 0 if they have the same sign. The N flag may therefore be set to 1 when the quotient is zero.

**2.2.27 (2) DIVXS (W)****DIVXS (DIVide eXtend as Signed)****Divide Signed****Operation**

ERd ÷ Rs → ERd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | — | — |

**Assembly-Language Format**

DIVXS.W Rs, ERd

H: Previous value remains unchanged.

N: Set to 1 if the quotient is negative; otherwise cleared to 0.

Z: Set to 1 if the divisor is zero; otherwise cleared to 0.

V: Previous value remains unchanged.

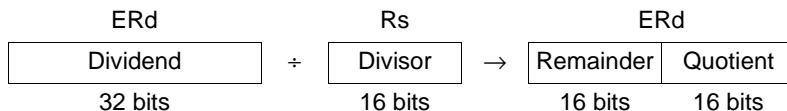
C: Previous value remains unchanged.

**Operand Size**

Word

**Description**

This instruction divides the contents of a 32-bit register ERd (destination operand) by the contents of a 16-bit register Rs (source operand) and stores the result in the 32-bit register ERd. The division is signed. The operation performed is 32 bits ÷ 16 bits → 16-bit quotient and 16-bit remainder. The quotient is placed in the lower 16 bits (Rd) of the 32-bit register ERd. The remainder is placed in the upper 16 bits (Ed). The sign of the remainder matches the sign of the dividend.



Valid results are not assured if division by zero is attempted or an overflow occurs.

**Available Registers**

ERd: ER0 to ER7

Rs: R0 to R7, E0 to E7

**DIVXS (DIVide eXtend as Signed)****Divide Signed****Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |           |           |                      | No. of States |
|-----------------|----------|----------|--------------------|-----------|-----------|----------------------|---------------|
|                 |          |          | 1st byte           | 2nd byte  | 3rd byte  | 4th byte             |               |
| Register direct | DIVXS.W  | Rs, ERd  | 0 ..... 1          | D ..... 0 | 5 ..... 3 | rs ..... 0 ..... erd | 21            |

**Notes**

The N flag is set to 1 if the dividend and divisor have different signs, and cleared to 0 if they have the same sign. The N flag may therefore be set to 1 when the quotient is zero.



**2.2.28 (1) DIVXU (B)****DIVXU (DIVide eXtend as Unsigned)****Divide****Operation**

Rd ÷ Rs → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | — | — |

**Assembly-Language Format**

DIVXU.B Rs, Rd

H: Previous value remains unchanged.

N: Set to 1 if the divisor is negative; otherwise cleared to 0.

Z: Set to 1 if the divisor is zero; otherwise cleared to 0.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction divides the contents of a 16-bit register Rd (destination operand) by the contents of an 8-bit register Rs (source operand) and stores the result in the 16-bit register Rd. The division is unsigned. The operation performed is 16 bits ÷ 8 bits → 8-bit quotient and 8-bit remainder. The quotient is placed in the lower 8 bits of Rd. The remainder is placed in the upper 8 bits of Rd.



Valid results are not assured if division by zero is attempted or an overflow occurs.

**Available Registers**

Rd: R0 to R7, E0 to E7

Rs: R0L to R7L, R0H to R7H

**DIVXU (DIVide eXtend as Unsigned)****Divide****Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |                   |          |          | No. of States |
|-----------------|----------|----------|--------------------|-------------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte          | 3rd byte | 4th byte |               |
| Register direct | DIVXU.B  | Rs, Rd   | 5<br>.....<br>1    | rs<br>.....<br>rd |          |          | 12            |

**Notes**

## 2.2.28 (2) DIVXU (W)

## DIVXU (DIVide eXtend as Unsigned)

Divide

## Operation

ERd ÷ Rs → ERd

## Condition Code

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | — | — |

## Assembly-Language Format

DIVXU.W Rs, ERd

H: Previous value remains unchanged.

N: Set to 1 if the divisor is negative; otherwise cleared to 0.

Z: Set to 1 if the divisor is zero; otherwise cleared to 0.

V: Previous value remains unchanged.

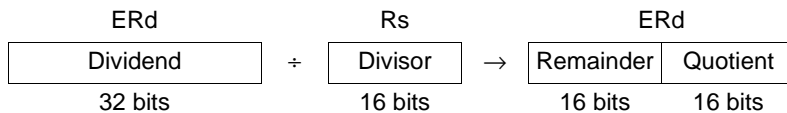
C: Previous value remains unchanged.

## Operand Size

Word

## Description

This instruction divides the contents of a 32-bit register ERd (destination operand) by the contents of a 16-bit register Rs (source register) and stores the result in the 32-bit register ERd. The division is unsigned. The operation performed is 32 bits ÷ 16 bits → 16-bit quotient and 16-bit remainder. The quotient is placed in the lower 16 bits (Rd) of the 32-bit register ERd. The remainder is placed in the upper 16 bits of (Ed).



Valid results are not assured if division by zero is attempted or an overflow occurs.

## Available Registers

ERd: ER0 to ER7

Rs: R0 to R7, E0 to E7

**DIVXU (DIVide eXtend as Unsigned)****Divide****Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |                                  |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------------------------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte                         | 3rd byte | 4th byte |               |
| Register direct | DIVXU.W  | Rs, ERd  | 5<br>.....<br>3    | rs<br>.....<br>0<br>.....<br>erd |          |          | 20            |

**Notes**

**2.2.29 (1) EEPMOV (B)****EEPMOV (MOVe data to EEPROM)****Block Data Transfer****Operation**

if R4L  $\neq$  0 then  
 repeat @ER5+  $\rightarrow$  @ER6+  
     R4L - 1  $\rightarrow$  R4L  
 until R4L = 0  
 else next;

**Condition Code**

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

H: Previous value remains unchanged.  
 N: Previous value remains unchanged.  
 Z: Previous value remains unchanged.  
 V: Previous value remains unchanged.  
 C: Previous value remains unchanged.

**Assembly-Language Format**

EEPMOV.B

**Operand Size**

—

**Description**

This instruction performs a block data transfer. It moves data from the memory location specified in ER5 to the memory location specified in ER6, increments ER5 and ER6, decrements R4L, and repeats these operations until R4L reaches zero. Execution then proceeds to the next instruction. The data transfer is performed a byte at a time, with R4L indicating the number of bytes to be transferred. The byte symbol in the assembly-language format designates the size of R4L (and limits the maximum number of bytes that can be transferred to 255). No interrupts are detected while the block transfer is in progress.

When the EEPMOV.B instruction ends, R4L contains 0 (zero), and ER5 and ER6 contain the last transfer address + 1.

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| —               | EEPMOV.B |          | 7<br>B             | 5<br>C   | 5<br>9   | 8<br>F   | 4 + 2n*       |

Note: \* n is the initial value of R4L. Although n bytes of data are transferred, 2(n + 1) data accesses are performed, requiring 2(n + 1) states. (n = 0, 1, 2, ..., 255).

**Notes**

This instruction first reads the memory locations indicated by ER5 and ER6, then carries out the block data transfer.

**2.2.29 (2) EEPMOV (W)****EEPMOV (MOVE data to EEPROM)****Block Data Transfer****Operation**

if R4 ≠ 0 then

repeat @ER5+ → @ER6+

R4 – 1 → R4

until R4 = 0

else next;

**Condition Code**

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

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Assembly-Language Format**

EEPMOV.W

**Operand Size**

—

**Description**

This instruction performs a block data transfer. It moves data from the memory location specified in ER5 to the memory location specified in ER6, increments ER5 and ER6, decrements R4, and repeats these operations until R4 reaches zero. Execution then proceeds to the next instruction. The data transfer is performed a byte at a time, with R4 indicating the number of bytes to be transferred. The word symbol in the assembly-language format designates the size of R4 (allowing a maximum 65535 bytes to be transferred). All interrupts are detected while the block transfer is in progress.

If no interrupt occurs while the EEPMOV.W instruction is executing, when the EEPMOV.W instruction ends, R4 contains 0 (zero), and ER5 and ER6 contain the last transfer address + 1.

If an interrupt occurs, interrupt exception handling begins after the current byte has been transferred. R4 indicates the number of bytes remaining to be transferred. ER5 and ER6 indicate the next transfer addresses. The program counter value pushed onto the stack in interrupt exception handling is the address of the next instruction after the EEPMOV.W instruction.

See the note on EEPMOV.W instruction and interrupt.

**EEPMOV (MOVE data to EEPROM)****Block Data Transfer****Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| —               | EEPMOV.W |          | 7 : B              | D : 4    | 5 : 9    | 8 : F    | 4 + 2n*       |

Note: \* n is the initial value of R4. Although n bytes of data are transferred, 2(n + 1) data accesses are performed, requiring 2(n + 1) states. (n = 0, 1, 2, ..., 65535).

**Notes**

This instruction first reads memory at the addresses indicated by ER5 and ER6, then carries out the block data transfer.

**EEPMOV.W Instruction and Interrupt**

If an interrupt request occurs while the EEPMOV.W instruction is being executed, interrupt exception handling is carried out after the current byte has been transferred. Register contents are then as follows:

ER5: address of the next byte to be transferred

ER6: destination address of the next byte

R4: number of bytes remaining to be transferred

The program counter value pushed on the stack in interrupt exception handling is the address of the next instruction after the EEPMOV.W instruction. Programs should be coded as follows to allow for interrupts during execution of the EEPMOV.W instruction.

**Example:**

```
L1: EEPMOV.W
      MOV.W    R4, R4
      BNE     L1
```

Interrupt requests other than NMI are not accepted if they are masked in the CPU.

During execution of the EEPMOV.B instruction no interrupts are accepted, including NMI.

## 2.2.30 (1) EXTS (W)

## EXTS (EXTend as Signed)

Sign Extension

## Operation

(&lt;Bit 7&gt; of Rd) → (&lt;bits 15 to 8&gt; of Rd)

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

## Assembly-Language Format

EXTS.W Rd

## Operand Size

Word

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

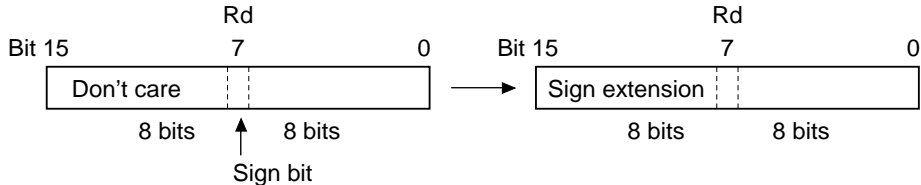
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

## Description

This instruction copies the sign of the lower 8 bits in a 16-bit register Rd in the upward direction (copies Rd bit 7 to bits 15 to 8) to extend the data to signed word data.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | EXTS.W   | Rd       | 1 7                | D rd     |          |          | 1             |

## Notes



## 2.2.30 (2) EXTS (L)

## EXTS (EXTend as Signed)

## Sign Extension

## Operation

(<Bit 15> of ERd) → (<bits 31 to 16> of ERd)

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

## Assembly-Language Format

EXTS.L ERd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

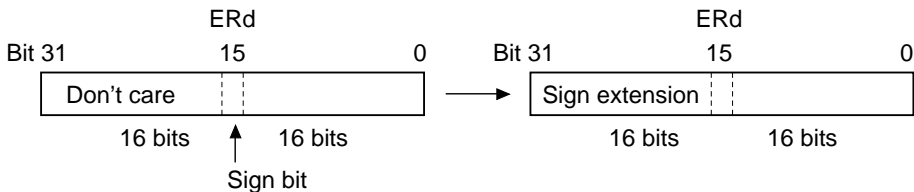
C: Previous value remains unchanged.

## Operand Size

Longword

## Description

This instruction copies the sign of the lower 16 bits in a 32-bit register ERd in the upward direction (copies ERd bit 15 to bits 31 to 16) to extend the data to signed longword data.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |           |          |          | No. of States |
|-----------------|----------|----------|--------------------|-----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte  | 3rd byte | 4th byte |               |
| Register direct | EXTS.L   | ERd      | 1 : 7              | F : 0:erd |          |          | 1             |

## Notes

## 2.2.31 (1) EXTU (W)

EXTU (EXTend as Unsigned)

Zero Extension

## Operation

0 → (&lt;bits 15 to 8&gt; of Rd)

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | 0 | ↕ | 0 | — |

## Assembly-Language Format

EXTU.W Rd

H: Previous value remains unchanged.

N: Always cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

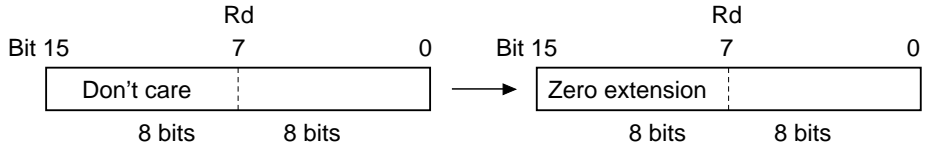
C: Previous value remains unchanged.

## Operand Size

Word

## Description

This instruction extends the lower 8 bits in a 16-bit register Rd to word data by padding with zeros. That is, it clears the upper 8 bits of Rd (bits 15 to 8) to 0.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |            |          |          | No. of States |
|-----------------|----------|----------|--------------------|------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Register direct | EXTU.W   | Rd       | 1 ..... 7          | 5 ..... rd |          |          | 1             |

## Notes

## 2.2.31 (2) EXTU (L)

EXTU (EXTend as Unsigned)

Zero Extension

## Operation

0 → (&lt;bits 31 to 16&gt; of ERd)

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | 0 | ↕ | 0 | — |

## Assembly-Language Format

EXTU.L ERd

H: Previous value remains unchanged.

N: Always cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

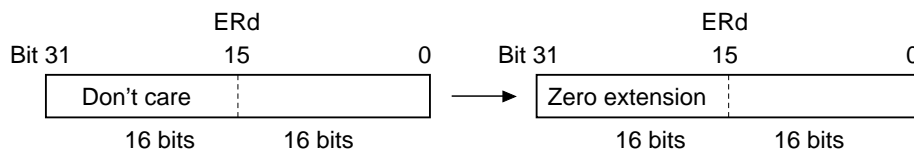
C: Previous value remains unchanged.

## Operand Size

Longword

## Description

This instruction extends the lower 16 bits (general register Rd) in a 32-bit register ERd to longword data by padding with zeros. That is, it clears the upper 16 bits of ERd (bits 31 to 16) to 0.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |                 |          |          | No. of States |
|-----------------|----------|----------|--------------------|-----------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte        | 3rd byte | 4th byte |               |
| Register direct | EXTU.L   | ERd      | 1<br>⋮<br>7        | 7<br>⋮<br>0:erd |          |          | 1             |

## Notes

**2.2.32 (1) INC (B)****INC (INCRement)****Increment****Operation**

Rd + 1 → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | ↕ | — |

**Assembly-Language Format**

INC .B Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction increments an 8-bit register Rd (destination operand) and stores the result in the 8-bit register Rd.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | INC.B    | Rd       | 0                  | A        | 0        | rd       | 1             |

**Notes**

An overflow is caused by the operation H'7F + 1 → H'80.

## 2.2.32 (2) INC (W)

## INC (INCRement)

Increment

## Operation

Rd + 1 → Rd  
 Rd + 2 → Rd

## Condition Code

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | ↕ | — |

## Assembly-Language Format

INC.W #1, Rd  
 INC.W #2, Rd

- H: Previous value remains unchanged.  
 N: Set to 1 if the result is negative; otherwise cleared to 0.  
 Z: Set to 1 if the result is zero; otherwise cleared to 0.  
 V: Set to 1 if an overflow occurs; otherwise cleared to 0.  
 C: Previous value remains unchanged.

## Operand Size

Word

## Description

This instruction adds the immediate value 1 or 2 to the contents of a 16-bit register Rd (destination operand) and stores the result in the 16-bit register Rd.

## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | INC.W    | #1, Rd   | 0   B              | 5   rd   |          |          | 1             |
| Register direct | INC.W    | #2, Rd   | 0   B              | D   rd   |          |          | 1             |

## Notes

An overflow is caused by the operations H'7FFF + 1 → H'8000, H'7FFF + 2 → H'8001, and H'7FFE + 2 → H'8000.

## 2.2.32 (3) INC (L)

## INC (INCRement)

Increment

## Operation

ERd + 1 → ERd

ERd + 2 → ERd

## Condition Code

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | ↕ | — |

## Assembly-Language Format

INC .L #1, ERd

INC .L #2, ERd

## Operand Size

Longword

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Previous value remains unchanged.

## Description

This instruction adds the immediate value 1 or 2 to the contents of a 32-bit register ERd (destination operand) and stores the result in the 32-bit register ERd.

## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | INC.L    | #1, ERd  | 0                  | B        | 7        | 0 erd    | 1             |
| Register direct | INC.L    | #2, ERd  | 0                  | B        | F        | 0 erd    | 1             |

## Notes

An overflow is caused by the operations H'7FFFFFFF + 1 → H'80000000, H'7FFFFFFF + 2 → H'80000001, and H'7FFFFFFE + 2 → H'80000000.

## 2.2.33 JMP

### JMP (JuMP)

### Unconditional Branch

#### Operation

Effective address → PC

#### Condition Code

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

#### Assembly-Language Format

JMP <EA>

H: Previous value remains unchanged.  
 N: Previous value remains unchanged.  
 Z: Previous value remains unchanged.  
 V: Previous value remains unchanged.  
 C: Previous value remains unchanged.

#### Operand Size

—

#### Description

This instruction branches unconditionally to a specified effective address.

#### Available Registers

ERn: ER0 to ER7

#### Operand Format and Number of States Required for Execution

| Addressing Mode   | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |          |   |
|-------------------|----------|----------|--------------------|----------|----------|----------|---------------|----------|---|
|                   |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte | Normal        | Advanced |   |
| Register indirect | JMP      | @ERn     | 5                  | 9        | 0        | ern      | 0             | 2        |   |
| Absolute address  | JMP      | @aa:24   | 5                  | A        | abs      |          |               | 3        |   |
| Memory indirect   | JMP      | @@aa:8   | 5                  | B        | abs      |          |               | 4        | 5 |

#### Notes

The structure of the branch address and the number of states required for execution differ between normal mode and advanced mode.

Ensure that the branch destination address is even.

## 2.2.34 JSR

## JSR (Jump to SubRoutine)

## Jump to Subroutine

## Operation

PC → @-SP

Effective address → PC

## Condition Code

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

## Assembly-Language Format

JSR &lt;EA&gt;

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

## Operand Size

—

## Description

This instruction pushes the program counter onto the stack as a return address, then branches to a specified effective address. The program counter value pushed onto the stack is the address of the instruction following the JSR instruction.

## Available Registers

ERn: ER0 to ER7

## Operand Format and Number of States Required for Execution

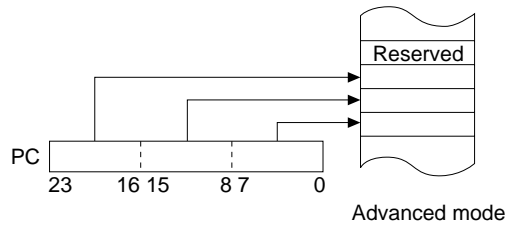
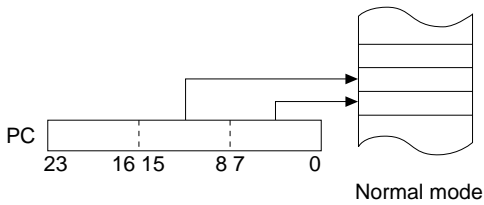
| Addressing Mode   | Mnemonic | Operands | Instruction Format |           |          |          | No. of States |          |
|-------------------|----------|----------|--------------------|-----------|----------|----------|---------------|----------|
|                   |          |          | 1st byte           | 2nd byte  | 3rd byte | 4th byte | Normal        | Advanced |
| Register indirect | JSR      | @ERn     | 5                  | D 0:ern 0 |          |          | 3             | 4        |
| Absolute address  | JSR      | @aa:24   | 5                  | E         | abs      |          | 4             | 5        |
| Memory indirect   | JSR      | @@aa:8   | 5                  | F         | abs      |          | 4             | 6        |



**JSR (Jump to SubRoutine)****Jump to Subroutine****Notes**

The stack structure differs between normal mode and advanced mode. In normal mode only the lower 16 bits of the program counter are pushed onto the stack.

Ensure that the branch destination address is even.



## 2.2.35 (1) LDC (B)

## LDC (Load to Control register)

Load CCR

## Operation

&lt;EAs&gt; → CCR

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| ↑ | ↑  | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |

## Assembly-Language Format

LDC .B &lt;EAs&gt;, CCR

## Operand Size

Byte

- I: Loaded from the corresponding bit in the source operand.
- H: Loaded from the corresponding bit in the source operand.
- N: Loaded from the corresponding bit in the source operand.
- Z: Loaded from the corresponding bit in the source operand.
- V: Loaded from the corresponding bit in the source operand.
- C: Loaded from the corresponding bit in the source operand.

## Description

This instruction loads the source operand contents into the condition-code register (CCR).

No interrupt requests, including NMI, are accepted immediately after execution of this instruction.

## Available Registers

Rs: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands   | Instruction Format |            |          |          | No. of States |
|-----------------|----------|------------|--------------------|------------|----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Immediate       | LDC.B    | #xx:8, CCR | 0 ..... 7          | IMM        |          |          | 1             |
| Register direct | LDC.B    | Rs, CCR    | 0 ..... 3          | 0 ..... rs |          |          | 1             |

## Notes

## 2.2.35 (2) LDC (B)

**LDC (LoaD to Control register)****Load EXR****Operation**

&lt;EAs&gt; → EXR

**Condition Code**

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

**Assembly-Language Format**

LDC .B &lt;EAs&gt;, EXR

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction loads the source operand contents into the extended control register (EXR).

No interrupt requests, including NMI, are accepted for three states after execution of this instruction.

**Available Registers**

Rs: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands   | Instruction Format |          |          |          | No. of States |
|-----------------|----------|------------|--------------------|----------|----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | LDC.B    | #xx:8, EXR | 0   1              | 4   1    | 0   7    | IMM      | 2             |
| Register direct | LDC.B    | Rs, EXR    | 0   3              | 1   rs   |          |          | 1             |

**Notes**

**2.2.35 (3) LDC (W)****LDC (Load to Control register)****Load CCR****Operation**

(EAs) → CCR

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| ↕ | ↕  | ↕ | ↕ | ↕ | ↕ | ↕ | ↕ |

**Assembly-Language Format**

LDC .W &lt;EAs&gt;, CCR

**Operand Size**

Word

- I: Loaded from the corresponding bit in the source operand.
- H: Loaded from the corresponding bit in the source operand.
- N: Loaded from the corresponding bit in the source operand.
- Z: Loaded from the corresponding bit in the source operand.
- V: Loaded from the corresponding bit in the source operand.
- C: Loaded from the corresponding bit in the source operand.

**Description**

This instruction loads the source operand contents into the condition-code register (CCR).

Although CCR is a byte register, the source operand is word size. The contents of the even address are loaded into CCR.

No interrupt requests, including NMI, are accepted immediately after execution of this instruction.

**Available Registers**

ERs: ER0 to ER7

## LDC (LoaD to Control register)

## Load CCR

## Operand Format and Number of States Required for Execution

| Addressing Mode                       | Mnemonic | Operands          | Instruction Format |          |          |          |          |          |          |          |          |           | No. of States |   |   |      |  |   |
|---------------------------------------|----------|-------------------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|---------------|---|---|------|--|---|
|                                       |          |                   | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |               |   |   |      |  |   |
| Register indirect                     | LDC.W    | @ERs, CCR         | 0                  | 1        | 4        | 0        | 6        | 9        | 0        | ers      | 0        |           |               |   |   |      |  | 3 |
| Register indirect with displacement   | LDC.W    | @(d:16, ERs), CCR | 0                  | 1        | 4        | 0        | 6        | F        | 0        | ers      | 0        | disp      |               |   |   |      |  | 4 |
| Register indirect with post-increment | LDC.W    | @(d:32, ERs), CCR | 0                  | 1        | 4        | 0        | 7        | 8        | 0        | ers      | 0        | 6         | B             | 2 | 0 | disp |  | 6 |
| Register indirect with post-increment | LDC.W    | @ERs+, CCR        | 0                  | 1        | 4        | 0        | 6        | D        | 0        | ers      | 0        |           |               |   |   |      |  | 4 |
| Absolute address                      | LDC.W    | @aa:16, CCR       | 0                  | 1        | 4        | 0        | 6        | B        | 0        | 0        | 0        | abs       |               |   |   |      |  | 4 |
|                                       | LDC.W    | @aa:32, CCR       | 0                  | 1        | 4        | 0        | 6        | B        | 2        | 0        | 0        | abs       |               |   |   |      |  | 5 |

## Notes

**2.2.35 (4) LDC (W)****LDC (Load to Control register)****Load EXR**

---

**Operation**

(EAs) → EXR

**Condition Code**

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

---

**Assembly-Language Format**

LDC .W &lt;EAs&gt;, EXR

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

---

**Operand Size**

Word

---

**Description**

This instruction loads the source operand contents into the extended control register (EXR).

Although EXR is a byte register, the source operand is word size. The contents of the even address are loaded into EXR.

No interrupt requests, including NMI, are accepted for three states after execution of this instruction.

---

**Available Registers**

ERs: ER0 to ER7

## LDC (LoaD to Control register)

## Load EXR

## Operand Format and Number of States Required for Execution

| Addressing Mode                       | Mnemonic | Operands          | Instruction Format |          |          |          |          |          |          |          |          |           | No. of States |   |      |  |   |
|---------------------------------------|----------|-------------------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|---------------|---|------|--|---|
|                                       |          |                   | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |               |   |      |  |   |
| Register indirect                     | LDC.W    | @ERs, EXR         | 0                  | 1        | 4        | 1        | 6        | 9        | 0:ers    | 0        |          |           |               |   |      |  | 3 |
| Register indirect with displacement   | LDC.W    | @(d:16, ERs), EXR | 0                  | 1        | 4        | 1        | 6        | F        | 0:ers    | 0        | disp     |           |               |   |      |  | 4 |
| Register indirect with post-increment | LDC.W    | @(d:32, ERs), EXR | 0                  | 1        | 4        | 1        | 7        | 8        | 0:ers    | 0        | 6        | B         | 2             | 0 | disp |  | 6 |
| Register indirect with post-increment | LDC.W    | @ERs+, EXR        | 0                  | 1        | 4        | 1        | 6        | D        | 0:ers    | 0        |          |           |               |   |      |  | 4 |
| Absolute address                      | LDC.W    | @aa:16, EXR       | 0                  | 1        | 4        | 1        | 6        | B        | 0        | 0        | abs      |           |               |   |      |  | 4 |
|                                       | LDC.W    | @aa:32, EXR       | 0                  | 1        | 4        | 1        | 6        | B        | 2        | 0        |          |           | abs           |   |      |  | 5 |

## Notes

**2.2.36 LDM****LDM (Load to Multiple registers)****Restore Data from Stack****Operation**

@SP+ → ERn (register list)

**Condition Code**

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

**Assembly-Language Format**

LDM .L @SP+, <register list>

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Operand Size**

Longword

**Description**

This instruction restores data saved on the stack to a specified list of registers. Registers are restored in descending order of register number.

Two, three, or four registers can be restored by one LDM instruction. The following ranges can be specified in the register list.

Two registers: ER0–ER1, ER2–ER3, ER4–ER5, or ER6–ER7

Three registers: ER0–ER2 or ER4–ER6

Four registers: ER0–ER3 or ER4–ER7

**Available Registers**

ERn: ER0 to ER7



**LDM (Load to Multiple registers)****Restore Data from Stack****Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands             | Instruction Format |   |          |   |          |   |          |         | No. of States |
|-----------------|----------|----------------------|--------------------|---|----------|---|----------|---|----------|---------|---------------|
|                 |          |                      | 1st byte           |   | 2nd byte |   | 3rd byte |   | 4th byte |         |               |
| —               | LDM.L    | @SP+,<br>(ERn-ERn+1) | 0                  | 1 | 1        | 0 | 6        | D | 7        | 0:ern+1 | 7             |
| —               | LDM.L    | @SP+,<br>(ERn-ERn+2) | 0                  | 1 | 2        | 0 | 6        | D | 7        | 0:ern+2 | 9             |
| —               | LDM.L    | @SP+,<br>(ERn-ERn+3) | 0                  | 1 | 3        | 0 | 6        | D | 7        | 0:ern+3 | 11            |

**Notes**

## 2.2.37 LDMAC

## LDMAC (LoaD to MAC register)

## Load MAC Register

**Operation**

ERs → MACH

or

ERs → MACL

**Condition Code**

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

**Assembly-Language Format**

LDMAC ERs, MAC register

**Operand Size**

Longword

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Description**

This instruction moves the contents of a general register to a multiply-accumulate register (MACH or MACL). If the transfer is to MACH, only the lowest 10 bits of the general register are transferred.

Supported only by the H8S/2600 CPU.

**Available Registers**

ERs: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands  | Instruction Format |          |          |          | No. of States |
|-----------------|----------|-----------|--------------------|----------|----------|----------|---------------|
|                 |          |           | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | LDMAC    | ERs, MACH | 0 3                | 2 0ers   |          |          | 2*            |
| Register direct | LDMAC    | ERs, MACL | 0 3                | 3 0ers   |          |          | 2*            |

Note: \* A maximum of three additional states are required for execution of this instruction within three states after execution of a MAC instruction. For example, if there is a one-state instruction (such as NOP) between the MAC instruction and this instruction, this instruction will be two states longer.

The number of states may differ depending on the product. For details, refer to the relevant microcontroller hardware manual of the product in question.

**Notes**

Execution of this instruction clears the overflow flag in the multiplier to 0.

## 2.2.38 MAC

## MAC (Multiply and ACcumulate)

## Multiply and Accumulate

**Operation**

$(EAn) \times (EAm) + \text{MAC register} \rightarrow$

MAC register

$ERn + 2 \rightarrow ERn$

$ERm + 2 \rightarrow ERm$

**Assembly-Language Format**

MAC @ERn+, @ERm+

**Condition Code**

| I | UI | H | U | N  | Z  | V  | C |
|---|----|---|---|----|----|----|---|
| — | —  | — | — | —* | —* | —* | — |

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Operand Size**

—

**Description**

This instruction performs signed multiplication on two 16-bit operands at addresses given by the contents of general registers ERn and ERm, adds the 32-bit product to the contents of the MAC register, and stores the sum in the MAC register. After this operation, ERn and ERm are both incremented by 2.

The operation can be carried out in saturating or non-saturating mode, depending on the MACS bit in a system control register. (SYSCR)

See the relevant hardware manual for further information.

In non-saturating mode, MACH and MACL are concatenated to store a 42-bit result. The value of bit 41 is copied into the upper 22 bits of MACH as a sign extension.

In saturating mode, only MACL is valid, and the result is limited to the range from H'80000000 (minimum value) to H'7FFFFFFF (maximum value). If the result overflows in the negative direction, H'80000000 (the minimum value) is stored in MACL. If the result overflows in the positive direction, H'7FFFFFFF (the maximum value) is stored in MACL. The LSB of the MACH register indicates the status of the overflow flag (V-MULT) in the multiplier. Other bits retain their previous contents.

This instruction is supported only by the H8S/2600 CPU.

**MAC (Multiply and ACcumulate)****Multiply and Accumulate****Operand Format and Number of States Required for Execution**

| Addressing Mode                       | Mnemonic | Operands        | Instruction Format |          |          |             | No. of States |
|---------------------------------------|----------|-----------------|--------------------|----------|----------|-------------|---------------|
|                                       |          |                 | 1st byte           | 2nd byte | 3rd byte | 4th byte    |               |
| Register indirect with post-increment | MAC      | @ERn+,<br>@ERm+ | 0 1                | 6 0      | 6 D      | 0 erm 0 erm | 4             |

**Notes**

1. Flags (N, Z, V) indicating the result of the MAC instruction can be set in the condition-code register (CCR) by the STMAC instruction.
2. If ERn and ERm are the same register, the execution addresses are ERn and ERn + 2. After execution, the value of ERn is ERn + 4.
3. If MACS is modified during execution of a MAC instruction, the result cannot be guaranteed. It is essential to wait for at least three states after a MAC instruction before modifying MACS.

**Further Explanation of Instructions Using Multiplier**

## 1. Modification of flags

The multiplier has N-MULT, Z-MULT, and V-MULT flags that indicate the results of MAC instructions. These flags are separated from the condition-code register (CCR). The values of these flags can be set in the N, Z, and V flags of the CCR only by the STMAC instruction.

N-MULT and Z-MULT are modified only by MAC instructions. V-MULT retains a value indicating whether an overflow has occurred in the past, until it is cleared by execution of the CLRMAC or LDMAC instruction.

The setting and clearing conditions for these flags are given below.

- N-MULT (negative flag)

|                     |  |
|---------------------|--|
| Saturating mode     | Set when bit 31 of register MACL is set to 1 by execution of a MAC instruction         |
|                     | Cleared when bit 31 of register MACL is cleared to 0 by execution of a MAC instruction |
| Non-saturating mode | Set when bit 41 of register MACH is set to 1 by execution of a MAC instruction         |
|                     | Cleared when bit 41 of register MACH is cleared to 0 by execution of a MAC instruction |

**MAC (Multiply and ACcumulate)****Multiply and Accumulate**

- Z-MULT (zero flag)

|                     |  |
|---------------------|--|
| Saturating mode     | Set when register MACL is cleared to 0 by execution of a MAC instruction                 |
|                     | Cleared when register MACL is not cleared to 0 by execution of a MAC instruction         |
| Non-saturating mode | Set when registers MACH and MACL are both cleared to 0 by execution of a MAC instruction |
|                     | Cleared when register MACH or MACL is not cleared to 0 by execution of a MAC instruction |

- V-MULT (overflow flag)

|                     |  |
|---------------------|--|
| Saturating mode     | Set when the result of the MAC instruction overflows the range from H'80000000 (minimum) to H'7FFFFFFF (maximum)                             |
|                     | Cleared when a CLRMAC or LDMAC instruction is executed<br>Note: Not cleared when the result of the MAC instruction is within the above range |
| Non-saturating mode | Set when the result of the MAC instruction overflows the range from H'2000000000 (minimum) to H'1FFFFFFFFF (maximum)                         |
|                     | Cleared when a CLRMAC or LDMAC instruction is executed<br>Note: Not cleared when the result of the MAC instruction is within the above range |

The N-MULT, Z-MULT, and V-MULT flags are not modified by switching between saturating and non-saturating modes, or by execution of a multiply instruction (MULXU or MULXS).

## 2. Example

CLRMAC

MAC @ER1+, @ER2+

MAC @ER1+, @ER2+ ← Overflow occurs

:

MAC @ER1+, @ER2+ ← Result = 0

NOP

STMACH MACH, ER3 ← CCR (N = 0, Z = 1, V = 1)

CLRMAC

STMACH MACH, ER3 ← CCR (N = 0, Z = 1, V = 0)

**2.2.39 (1) MOV (B)****MOV (MOVE data)****Move****Operation**

Rs → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

MOV.B Rs, Rd

H: Previous value remains unchanged.

N: Set to 1 if the transferred data is negative; otherwise cleared to 0.

Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction transfers one byte of data from an 8-bit register Rs to an 8-bit register Rd, tests the transferred data, and sets condition-code flags according to the result.

**Available Registers**

Rs: R0L to R7L, R0H to R7H

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | MOV.B    | Rs, Rd   | 0 C                | rs rd    |          |          | 1             |

**Notes**

## 2.2.39 (2) MOV (W)

## MOV (MOVE data)

Move

## Operation

Rs → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

## Assembly-Language Format

MOV.W Rs, Rd

- H: Previous value remains unchanged.  
 N: Set to 1 if the transferred data is negative; otherwise cleared to 0.  
 Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

## Operand Size

Word

## Description

This instruction transfers one word of data from a 16-bit register Rs to a 16-bit register Rd, tests the transferred data, and sets condition-code flags according to the result.

## Available Registers

Rd: R0 to R7, E0 to E7

Rs: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | MOV.W    | Rs, Rd   | 0 ‖ D              | rs ‖ rd  |          |          | 1             |

## Notes

**2.2.39 (3) MOV (L)****MOV (MOVE data)****Move****Operation**

ERs → ERd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

MOV.L ERs, ERd

H: Previous value remains unchanged.

N: Set to 1 if the transferred data is negative; otherwise cleared to 0.

Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Longword

**Description**

This instruction transfers one word of data from a 32-bit register ERs to a 32-bit register ERd, tests the transferred data, and sets condition-code flags according to the result.

**Available Registers**

ERd: ER0 to ER7

ERs: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |           |          |          | No. of States |
|-----------------|----------|----------|--------------------|-----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte  | 3rd byte | 4th byte |               |
| Register direct | MOV.L    | ERs, ERd | 0 F                | 1ers 0erd |          |          | 1             |

**Notes**



**2.2.39 (4) MOV (B)****MOV (MOVE data)****Move****Operation**

(EAs) → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

MOV .B &lt;EAs&gt;, Rd

- H: Previous value remains unchanged.  
 N: Set to 1 if the transferred data is negative; otherwise cleared to 0.  
 Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction transfers the source operand contents to an 8-bit register Rd, tests the transferred data, and sets condition-code flags according to the result.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

ERs: ER0 to ER7

## MOV (MOVE data)

Move

## Operand Format and Number of States Required for Execution

| Addressing Mode                       | Mnemonic | Operands         | Instruction Format |          |          |          |          |          |          |          | No. of States |  |   |
|---------------------------------------|----------|------------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|--|---|
|                                       |          |                  | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |  |   |
| Immediate                             | MOV.B    | #xx:8, Rd        | F                  | rd       |          |          |          |          |          |          |               |  | 1 |
| Register indirect                     | MOV.B    | @ERS, Rd         | 6                  | 0:ers    | rd       |          |          |          |          |          |               |  | 2 |
| Register indirect with displacement   | MOV.B    | @(d:16, ERs), Rd | 6                  | 0:ers    | rd       | disp     |          |          |          |          |               |  | 3 |
|                                       | MOV.B    | @(d:32, ERs), Rd | 7                  | 8        | 0:ers    | 0        | 6        | A        | 2        | rd       | disp          |  | 5 |
| Register indirect with post-increment | MOV.B    | @ERS+, Rd        | 6                  | C        | 0:ers    | rd       |          |          |          |          |               |  | 3 |
|                                       | MOV.B    | @aa:8, Rd        | 2                  | rd       | abs      |          |          |          |          |          |               |  | 2 |
| Absolute address                      | MOV.B    | @aa:16, Rd       | 6                  | A        | 0        | rd       | abs      |          |          |          |               |  | 3 |
|                                       | MOV.B    | @aa:32, Rd       | 6                  | A        | 2        | rd       | abs      |          |          |          |               |  | 4 |

**Notes**

The MOV.B @ER7+, Rd instruction should never be used, because it leaves an odd value in the stack pointer (ER7). For details refer to section 3.3, Exception-Handling State, or to the relevant hardware manual.

For the @aa:8/@aa:16 access range, refer to the relevant microcontroller hardware manual.

**2.2.39 (5) MOV (W)****MOV (MOVE data)****Move****Operation**

(EAs) → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

MOV.W &lt;EAs&gt;, Rd

- H: Previous value remains unchanged.  
 N: Set to 1 if the transferred data is negative; otherwise cleared to 0.  
 Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

**Operand Size**

Word

**Description**

This instruction transfers the source operand contents to a 16-bit register Rd, tests the transferred data, and sets condition-code flags according to the result.

**Available Registers**

Rd: R0 to R7, E0 to E7

ERs: ER0 to ER7

## MOV (MOVe data)

Move

## Operand Format and Number of States Required for Execution

| Addressing Mode                       | Mnemonic | Operands         | Instruction Format |          |          |          |          |          |          |          | No. of States |  |   |
|---------------------------------------|----------|------------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|--|---|
|                                       |          |                  | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |  |   |
| Immediate                             | MOV.W    | #xx:16, Rd       | 7                  | 9        | 0        | rd       | IMM      |          |          |          |               |  | 2 |
| Register indirect                     | MOV.W    | @ERS, Rd         | 6                  | 9        | 0:ers    | rd       |          |          |          |          |               |  | 2 |
| Register indirect with displacement   | MOV.W    | @(d:16, ERs), Rd | 6                  | F        | 0:ers    | rd       | disp     |          |          |          |               |  | 3 |
| Register indirect with post-increment | MOV.W    | @(d:32, ERs), Rd | 7                  | 8        | 0:ers    | 0        | 6        | B        | 2        | rd       | disp          |  | 5 |
| Absolute address                      | MOV.W    | @ERS+, Rd        | 6                  | D        | 0:ers    | rd       |          |          |          |          |               |  | 3 |
|                                       | MOV.W    | @aa:16, Rd       | 6                  | B        | 0        | rd       | abs      |          |          |          |               |  | 3 |
|                                       | MOV.W    | @aa:32, Rd       | 6                  | B        | 2        | rd       | abs      |          |          |          |               |  | 4 |

## Notes

1. The source operand <EAs> must be located at an even address.
2. In machine language, MOV.W @ER7+, Rd is identical to POP.W Rd.

## 2.2.39 (6) MOV (L)

## MOV (MOVE data)

Move

## Operation

(EAs) → ERd

## Condition Code

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | 0 | — |

## Assembly-Language Format

MOV.L &lt;EAs&gt;, ERd

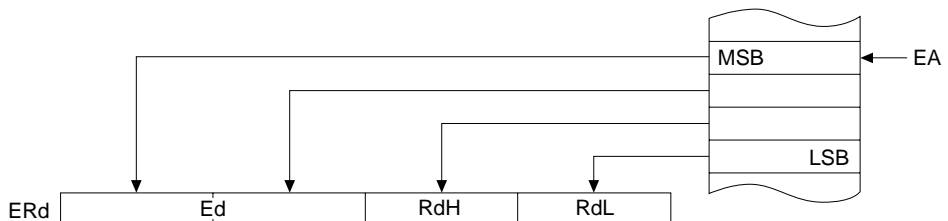
- H: Previous value remains unchanged.  
 N: Set to 1 if the transferred data is negative; otherwise cleared to 0.  
 Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

## Operand Size

Longword

## Description

This instruction transfers the source operand contents to a specified 32-bit register (ERd), tests the transferred data, and sets condition-code flags according to the result. The first memory word located at the effective address is stored in extended register Ed. The next word is stored in general register Rd.



## Available Registers

ERs: ER0 to ER7

ERd: ER0 to ER7

## MOV (MOVe data)

Move

## Operand Format and Number of States Required for Execution

| Addressing Mode                       | Mnemonic | Operands          | Instruction Format |          |          |          |          |          |             |          |          |           | No. of States |      |   |
|---------------------------------------|----------|-------------------|--------------------|----------|----------|----------|----------|----------|-------------|----------|----------|-----------|---------------|------|---|
|                                       |          |                   | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte    | 8th byte | 9th byte | 10th byte |               |      |   |
| Immediate                             | MOV.L    | #x:32, Rd         | 7                  | A        | 0        | 0:erd    | IMM      |          |             |          |          |           |               |      | 3 |
| Register indirect                     | MOV.L    | @ERS, ERd         | 0                  | 1        | 0        | 0        | 6        | 9        | 0:ers;0:erd |          |          |           |               |      | 4 |
| Register indirect with displacement   | MOV.L    | @(d:16, ERs), ERd | 0                  | 1        | 0        | 0        | 6        | F        | 0:ers;0:erd | disp     |          |           |               |      | 5 |
| Register indirect with post-increment | MOV.L    | @(d:32, ERs), ERd | 0                  | 1        | 0        | 0        | 7        | 8        | 0:ers       | 0        | 6        | 2         | 0:erd         | disp | 7 |
| Absolute address                      | MOV.L    | @ERS+, ERd        | 0                  | 1        | 0        | 0        | 6        | D        | 0:ers;0:erd |          |          |           |               |      | 5 |
| Absolute address                      | MOV.L    | @aa:16, ERd       | 0                  | 1        | 0        | 0        | 6        | B        | 0           | 0:erd    | abs      |           |               |      | 5 |
|                                       | MOV.L    | @aa:32, ERd       | 0                  | 1        | 0        | 0        | 6        | B        | 2           | 0:erd    | abs      |           |               |      | 6 |

## Notes

1. The source operand <EAs> must be located at an even address.
2. In machine language, MOV.L @R7+, ERd is identical to POPL ERd.

**2.2.39 (7) MOV (B)****MOV (MOVE data)****Move****Operation**

Rs → (EAd)

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

MOV .B Rs, &lt;EAd&gt;

- H: Previous value remains unchanged.  
 N: Set to 1 if the transferred data is negative; otherwise cleared to 0.  
 Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction transfers the contents of an 8-bit register Rs (source operand) to a destination location, tests the transferred data, and sets condition-code flags according to the result.

**Available Registers**

Rs: R0L to R7L, R0H to R7H

ERd: ER0 to ER7

## MOV (MOVe data)

Move

## Operand Format and Number of States Required for Execution

| Addressing Mode                      | Mnemonic | Operands           | Instruction Format |          |          |          |          |          |          |          | No. of States |  |  |   |
|--------------------------------------|----------|--------------------|--------------------|----------|----------|----------|----------|----------|----------|----------|---------------|--|--|---|
|                                      |          |                    | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |  |  |   |
| Register indirect                    | MOV.B    | Rs, @ERd           | 6                  | 8        | 1:erd    | rs       |          |          |          |          |               |  |  | 2 |
| Register indirect with displacement  | MOV.B    | Rs, @({d:16, ERd}) | 6                  | E        | 1:erd    | rs       | disp     |          |          |          |               |  |  | 3 |
| Register indirect with pre-decrement | MOV.B    | Rs, @({d:32, ERd}) | 7                  | 8        | 0:erd    | 0        | 6        | A        | A        | rs       | disp          |  |  | 5 |
| Absolute address                     | MOV.B    | Rs, @-ERd          | 6                  | C        | 1:erd    | rs       |          |          |          |          |               |  |  | 3 |
|                                      | MOV.B    | Rs, @aa:8          | 3                  | rs       | abs      |          |          |          |          |          |               |  |  | 2 |
|                                      | MOV.B    | Rs, @aa:16         | 6                  | A        | 8        | rs       | abs      |          |          |          |               |  |  | 3 |
|                                      | MOV.B    | Rs, @aa:32         | 6                  | A        | A        | rs       | abs      |          |          |          |               |  |  | 4 |

## Notes

1. The MOV.B Rs, @-ER7 instruction should never be used, because it leaves an odd value in the stack pointer (ER7). For details refer to section 3.3, Exception-Handling State, or to the relevant hardware manual.
2. Execution of MOV.B RnL, @-ERn or MOV.B RnH, @-ERn first decrements ERn by one, then transfers the designated part (RnL or RnH) of the resulting ERn value.



**2.2.39 (8) MOV (W)****MOV (MOVE data)****Move****Operation**

Rs → (EAd)

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

MOV.W Rs, &lt;EAd&gt;

- H: Previous value remains unchanged.  
 N: Set to 1 if the transferred data is negative; otherwise cleared to 0.  
 Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

**Operand Size**

Word

**Description**

This instruction transfers the contents of a 16-bit register Rs (source operand) to a destination location, tests the transferred data, and sets condition-code flags according to the result.

**Available Registers**

Rs: R0 to R7, E0 to E7

ERd: ER0 to ER7

## MOV (MOVe data)

Move

## Operand Format and Number of States Required for Execution

| Addressing Mode                      | Mnemonic | Operands          | Instruction Format |                  |          |          |          |          |          |          | No. of States |   |
|--------------------------------------|----------|-------------------|--------------------|------------------|----------|----------|----------|----------|----------|----------|---------------|---|
|                                      |          |                   | 1st byte           | 2nd byte         | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte |               |   |
| Register indirect                    | MOV.W    | Rs, @ERd          | 6                  | 9<br>1:erd<br>rs |          |          |          |          |          |          |               | 2 |
| Register indirect with displacement  | MOV.W    | Rs, @(d:16, ERd)  | 6                  | F<br>1:erd<br>rs | disp     |          |          |          |          |          |               | 3 |
| Register indirect with pre-decrement | MOV.W    | Rs, @-(d:32, ERd) | 7                  | 8<br>0:erd<br>0  | 6        | B        | A        | rs       | disp     |          |               | 5 |
|                                      | MOV.W    | Rs, @-ERd         | 6                  | D<br>1:erd<br>rs |          |          |          |          |          |          |               | 3 |
| Absolute address                     | MOV.W    | Rs, @aa:16        | 6                  | B<br>8           | abs      |          |          |          |          |          |               | 3 |
|                                      | MOV.W    | Rs, @aa:32        | 6                  | B<br>A           | abs      |          |          |          |          |          |               | 4 |

## Notes

1. The destination operand <EAd> must be located at an even address.
2. In machine language, MOV.W Rs, @-ER7 is identical to PUSH.W Rs.
3. When MOV.W Rn, @-ERn is executed, the transferred value comes from (value of ERn before execution) - 2.

## 2.2.39 (9) MOV (L)

## MOV (MOVE data)

Move

## Operation

ERs → (EAd)

## Condition Code

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | 0 | — |

## Assembly-Language Format

MOV.L ERs, &lt;EAd&gt;

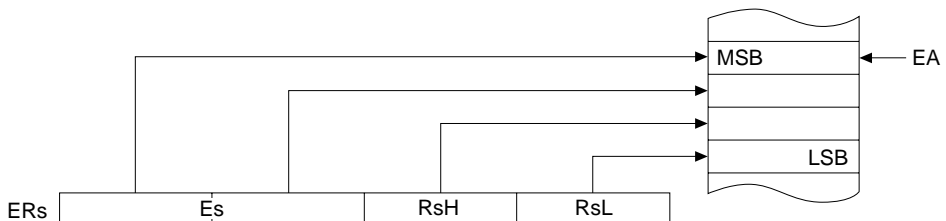
- H: Previous value remains unchanged.  
 N: Set to 1 if the transferred data is negative; otherwise cleared to 0.  
 Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

## Operand Size

Longword

## Description

This instruction transfers the contents of a 32-bit register ERs (source operand) to a destination location, tests the transferred data, and sets condition-code flags according to the result. The extended register (Es) contents are stored at the first word indicated by the effective address. The general register (Rs) contents are stored at the next word.



## Available Registers

ERs: ER0 to ER7

ERd: ER0 to ER7

## MOV (MOVe data)

Move

## Operand Format and Number of States Required for Execution

| Addressing Mode                      | Mnemonic | Operands          | Instruction Format |          |          |          |          |          |            |          |          |           | No. of States |      |  |  |   |
|--------------------------------------|----------|-------------------|--------------------|----------|----------|----------|----------|----------|------------|----------|----------|-----------|---------------|------|--|--|---|
|                                      |          |                   | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte   | 8th byte | 9th byte | 10th byte |               |      |  |  |   |
| Register indirect                    | MOVL     | ERs, @ERd         | 0                  | 1        | 0        | 0        | 6        | 9        | 1:erc0:ers |          |          |           |               |      |  |  | 4 |
| Register indirect with displacement  | MOVL     | ERs, @(d:16, ERd) | 0                  | 1        | 0        | 0        | 6        | F        | 1:erc0:ers | disp     |          |           |               |      |  |  | 5 |
| Register indirect with pre-decrement | MOVL     | ERs, @(d:32, ERd) | 0                  | 1        | 0        | 0        | 7        | 8        | 0:erc: 0   | 6        | B        | A         | 0:ers         | disp |  |  | 7 |
| Absolute address                     | MOVL     | ERs, @-ERd        | 0                  | 1        | 0        | 0        | 6        | D        | 1:erc0:ers |          |          |           |               |      |  |  | 5 |
|                                      | MOVL     | ERs, @aa:16       | 0                  | 1        | 0        | 0        | 6        | B        | 8:0:ers    | abs      |          |           |               |      |  |  | 5 |
|                                      | MOVL     | ERs, @aa:32       | 0                  | 1        | 0        | 0        | 6        | B        | A:0:ers    |          |          |           | abs           |      |  |  | 6 |

## Notes

1. The destination operand <EAd> must be located at an even address.
2. In machine language, MOVL ERs, @-ER7 is identical to PUSH.L ERs.
3. When MOVL ERn, @-ERn is executed, the transferred value is (value of ERn before execution) - 4.

**2.2.40 MOVFPE****MOVFPE (MOVE From Peripheral with E clock)****Move Data with E Clock****Operation**

(EAs) → Rd  
Synchronized with E clock

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

MOVFPE @aa:16, Rd

H: Previous value remains unchanged.  
N: Set to 1 if the transferred data is negative; otherwise cleared to 0.  
Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.  
V: Always cleared to 0.  
C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction transfers memory contents specified by a 16-bit absolute address to a general register Rd in synchronization with an E clock, tests the transferred data, and sets condition-code flags according to the result.

Note: Avoid using this instruction in microcontrollers without an E clock output pin, or in single-chip mode.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode  | Mnemonic | Operands   | Instruction Format |              |          |          | No. of States |
|------------------|----------|------------|--------------------|--------------|----------|----------|---------------|
|                  |          |            | 1st byte           | 2nd byte     | 3rd byte | 4th byte |               |
| Absolute address | MOVFPE   | @aa:16, Rd | 6<br>⋮<br>A        | 4<br>⋮<br>rd | abs      |          | *             |

Note: \* For details, refer to the relevant microcontroller hardware manual.

**Notes**

1. This instruction cannot be used with addressing modes other than the above, and cannot transfer word data or longword data.
2. The number of states required for execution is variable. For details, refer to the relevant microcontroller hardware manual.

## 2.2.41 MOVTPPE

## MOVTPPE (MOVE To Peripheral with E clock)

## Move Data with E Clock

## Operation

Rs → (EAd)

Synchronized with E clock

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

## Assembly-Language Format

MOVTPPE Rs, @aa:16

## Operand Size

Byte

H: Previous value remains unchanged.

N: Set to 1 if the transferred data is negative; otherwise cleared to 0.

Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

## Description

This instruction transfers the contents of a general register Rs (source operand) to a destination location specified by a 16-bit absolute address in synchronization with an E clock, tests the transferred data, and sets condition-code flags according to the result.

Note: Avoid using this instruction in microcontrollers without an E clock output pin, or in single-chip mode.

## Available Registers

Rs: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode  | Mnemonic | Operands   | Instruction Format |              |          |          | No. of States |
|------------------|----------|------------|--------------------|--------------|----------|----------|---------------|
|                  |          |            | 1st byte           | 2nd byte     | 3rd byte | 4th byte |               |
| Absolute address | MOVTPPE  | Rs, @aa:16 | 6<br>⋮<br>A        | C<br>⋮<br>rs | abs      |          | *             |

Note: \* For details, refer to the relevant microcontroller hardware manual.

## Notes

1. This instruction cannot be used with addressing modes other than the above, and cannot transfer word data or longword data.
2. The number of states required for execution is variable. For details, refer to the relevant microcontroller hardware manual.

## 2.2.42 (1) MULXS (B)

**MULXS (MULTIPLY eXtend as Signed)****Multiply Signed****Operation**

Rd × Rs → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↑ | ↑ | — | — |

**Assembly-Language Format**

MULXS.B Rs, Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Previous value remains unchanged.

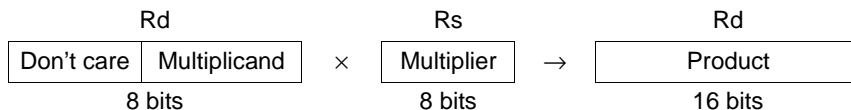
C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction multiplies the lower 8 bits of a 16-bit register Rd (destination operand) by the contents of an 8-bit register Rs (source operand) as signed data and stores the result in the 16-bit register Rd. If Rd is one of general registers R0 to R7, Rs can be the upper part (RdH) or lower part (RdL) of Rd. The operation performed is 8 bits × 8 bits → 16 bits signed multiplication.

**Available Registers**

Rd: R0 to R7, E0 to E7

Rs: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | MULXS.B  | Rs, Rd   | 0 1                | C 0      | 5 0      | rs rd    | 4*            |

Note: \* The number of states in the H8S/2000 CPU is 13.

A maximum of three additional states are required for execution of this instruction within three states after execution of a MAC instruction. For example, if there is a one-state instruction (such as NOP) between the MAC instruction and this instruction, this instruction will be two states longer.

The number of states may differ depending on the product. For details, refer to the relevant microcontroller hardware manual of the product in question.

**Notes**

## 2.2.42 (2) MULXS (W)

**MULXS (MULTIPLY eXtend as Signed)****Multiply Signed****Operation**

ERd × Rs → ERd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | — | — |

**Assembly-Language Format**

MULXS.W Rs, ERd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Previous value remains unchanged.

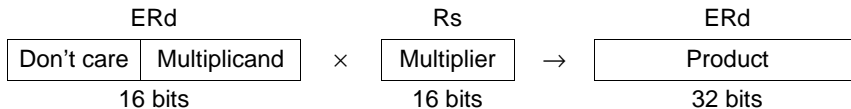
C: Previous value remains unchanged.

**Operand Size**

Word

**Description**

This instruction multiplies the lower 16 bits of a 32-bit register ERd (destination operand) by the contents of a 16-bit register Rs (source operand) as signed data and stores the result in the 32-bit register ERd. Rs can be the upper part (Ed) or lower part (Rd) of ERd. The operation performed is 16 bits × 16 bits → 32 bits signed multiplication.

**Available Registers**

ERd: ER0 to ER7

Rs: R0 to R7, E0 to E7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | MULXS.W  | Rs, ERd  | 0 1                | C 0      | 5 2      | rs 0 ERd | 5*            |

Note: \* The number of states in the H8S/2000 CPU is 21.

A maximum of three additional states are required for execution of this instruction within three states after execution of a MAC instruction. For example, if there is a one-state instruction (such as NOP) between the MAC instruction and this instruction, this instruction will be two states longer.

The number of states may differ depending on the product. For details, refer to the relevant microcontroller hardware manual of the product in question.

**Notes**



## 2.2.43 (1) MULXU (B)

**MULXU (MULTIPLY eXtend as Unsigned)****Multiply****Operation** $Rd \times Rs \rightarrow Rd$ **Condition Code**

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

**Assembly-Language Format**

MULXU.B Rs, Rd

**Operand Size**

Byte

H: Previous value remains unchanged.

N: Previous value remains unchanged.

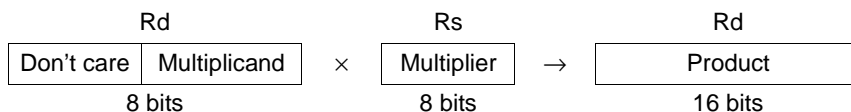
Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Description**

This instruction multiplies the lower 8 bits of a 16-bit register Rd (destination operand) by the contents of an 8-bit register Rs (source operand) as unsigned data and stores the result in the 16-bit register Rd. If Rd is one of general registers R0 to R7, Rs can be the upper part (RdH) or lower part (RdL) of Rd. The operation performed is 8 bits  $\times$  8 bits  $\rightarrow$  16 bits unsigned multiplication.

**Available Registers**

Rd: R0 to R7, E0 to E7

Rs: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | MULXU.B  | Rs, Rd   | 5 0                | rs rd    |          |          | 3*            |

Note: \* The number of states in the H8S/2000 CPU is 12.

A maximum of three additional states are required for execution of this instruction within three states after execution of a MAC instruction. For example, if there is a one-state instruction (such as NOP) between the MAC instruction and this instruction, this instruction will be two states longer.

The number of states may differ depending on the product. For details, refer to the relevant microcontroller hardware manual of the product in question.

**Notes**

## 2.2.43 (2) MULXU (W)

MULXU (MULtiple eXtend as Unsigned)

Multiply

## Operation

ERd × Rs → ERd

## Condition Code

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

## Assembly-Language Format

MULXU.W Rs, ERd

## Operand Size

Word

H: Previous value remains unchanged.

N: Previous value remains unchanged.

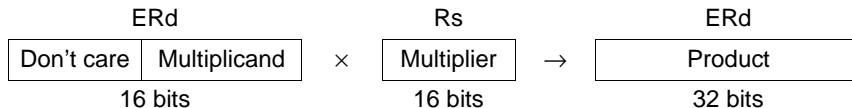
Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

## Description

This instruction multiplies the lower 16 bits of a 32-bit register ERd (destination operand) by the contents of a 16-bit register Rs (source operand) as unsigned data and stores the result in the 32-bit register ERd. Rs can be the upper part (Ed) or lower part (Rd) of ERd. The operation performed is 16 bits × 16 bits → 32 bits unsigned multiplication.



## Available Registers

ERd: ER0 to ER7

Rs: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | MULXU.W  | Rs, ERd  | 5 2                | rs 0erd  |          |          | 4*            |

Note: \* The number of states in the H8S/2000 CPU is 20.

A maximum of three additional states are required for execution of this instruction within three states after execution of a MAC instruction. For example, if there is a one-state instruction (such as NOP) between the MAC instruction and this instruction, this instruction will be two states longer.

The number of states may differ depending on the product. For details, refer to the relevant microcontroller hardware manual of the product in question.

## Notes

## 2.2.44 (1) NEG (B)

## NEG (NEGate)

Negate Binary Signed

## Operation

0 – Rd → Rd

## Condition Code

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

## Assembly-Language Format

NEG.B Rd

- H: Set to 1 if there is a borrow at bit 3; otherwise cleared to 0.
- N: Set to 1 if the result is negative; otherwise cleared to 0.
- Z: Set to 1 if the result is zero; otherwise cleared to 0.
- V: Set to 1 if an overflow occurs; otherwise cleared to 0.
- C: Set to 1 if there is a borrow at bit 7; otherwise cleared to 0.

## Operand Size

Byte

## Description

This instruction takes the two's complement of the contents of an 8-bit register Rd (destination operand) and stores the result in the 8-bit register Rd (subtracting the register contents from H'00). If the original contents of Rd were H'80, however, the result remains H'80.

## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | NEG.B    | Rd       | 1 : 7              | 8 : rd   |          |          | 1             |

## Notes

An overflow occurs if the original contents of Rd were H'80.

## 2.2.44 (2) NEG (W)

NEG (NEGate)

Negate Binary Signed

**Operation**

0 – Rd → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

NEG.W Rd

H: Set to 1 if there is a borrow at bit 11; otherwise cleared to 0.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Set to 1 if there is a borrow at bit 15; otherwise cleared to 0.

**Operand Size**

Word

**Description**

This instruction takes the two's complement of the contents of a 16-bit register Rd (destination operand) and stores the result in the 16-bit register Rd (subtracting the register contents from H'0000). If the original contents of Rd were H'8000, however, the result remains H'8000.

**Available Registers**

Rd: R0 to R7, E0 to E7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |            |          |          | No. of States |
|-----------------|----------|----------|--------------------|------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Register direct | NEG.W    | Rd       | 1 ..... 7          | 9 ..... rd |          |          | 1             |

**Notes**

An overflow occurs if the original contents of Rd were H'8000.

## 2.2.44 (3) NEG (L)

## NEG (NEGate)

Negate Binary Signed

## Operation

0 – ERd → ERd

## Condition Code

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

## Assembly-Language Format

NEG.L ERd

- H: Set to 1 if there is a borrow at bit 27; otherwise cleared to 0.
- N: Set to 1 if the result is negative; otherwise cleared to 0.
- Z: Set to 1 if the result is zero; otherwise cleared to 0.
- V: Set to 1 if an overflow occurs; otherwise cleared to 0.
- C: Set to 1 if there is a borrow at bit 31; otherwise cleared to 0.

## Operand Size

Longword

## Description

This instruction takes the two's complement of the contents of a 32-bit register ERd (destination operand) and stores the result in the 32-bit register ERd (subtracting the register contents from H'00000000). If the original contents of ERd were H'80000000, however, the result remains H'80000000.

## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | NEG.L    | ERd      | 1 7                | B 0:erd  |          |          | 1             |

## Notes

An overflow occurs if the original contents of ERd were H'80000000.

## 2.2.45 NOP

## NOP (No OPeration)

No Operation

## Operation

PC + 2 → PC

## Condition Code

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

## Assembly-Language Format

NOP

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

## Operand Size

—

## Description

This instruction only increments the program counter, causing the next instruction to be executed. The internal state of the CPU does not change.

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| —               | NOP      |          | 0 .....            | 0        | 0        | 0        | 1             |

## Notes

**2.2.46 (1) NOT (B)****NOT (NOT = logical complement)****Logical Complement****Operation**

¬ Rd → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

NOT.B Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction takes the one's complement of the contents of an 8-bit register Rd (destination operand) and stores the result in the 8-bit register Rd.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | NOT.B    | Rd       | 1                  | 7        | 0        | rd       | 1             |

**Notes**

**2.2.46 (2) NOT (W)****NOT (NOT = logical complement)****Logical Complement****Operation**

¬ Rd → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

NOT.W Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Word

**Description**

This instruction takes the one's complement of the contents of a 16-bit register Rd (destination operand) and stores the result in the 16-bit register Rd.

**Available Registers**

Rd: R0 to R7, E0 to E7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | NOT.W    | Rd       | 1                  | 7        | 1        | rd       | 1             |

**Notes**



**2.2.46 (3) NOT (L)****NOT (NOT = logical complement)****Logical Complement****Operation**

¬ ERd → ERd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

NOT.L ERd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Longword

**Description**

This instruction takes the one's complement of the contents of a 32-bit register ERd (destination operand) and stores the result in the 32-bit register ERd.

**Available Registers**

ERd: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | NOT.L    | ERd      | 1                  | 7        | 3        | 0 erd    | 1             |

**Notes**

**2.2.47 (1) OR (B)****OR (inclusive OR logical)****Logical OR****Operation**

Rd ∨ (EAs) → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

OR .B &lt;EAs&gt;, Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction ORs the source operand with the contents of an 8-bit register Rd (destination operand) and stores the result in the 8-bit register Rd.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

Rs: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands  | Instruction Format |          |          |          | No. of States |
|-----------------|----------|-----------|--------------------|----------|----------|----------|---------------|
|                 |          |           | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | OR.B     | #xx:8, Rd | C                  | rd       | IMM      |          | 1             |
| Register direct | OR.B     | Rs, Rd    | 1                  | 4        | rs       | rd       | 1             |

**Notes**

## 2.2.47 (2) OR (W)

OR (inclusive OR logical)

Logical OR

## Operation

Rd ∨ (EAs) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

## Assembly-Language Format

OR.W &lt;EAs&gt;, Rd

- H: Previous value remains unchanged.  
 N: Set to 1 if the result is negative; otherwise cleared to 0.  
 Z: Set to 1 if the result is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

## Operand Size

Word

## Description

This instruction ORs the source operand with the contents of a 16-bit register Rd (destination operand) and stores the result in the 16-bit register Rd.

## Available Registers

Rd: R0 to R7, E0 to E7

Rs: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands   | Instruction Format |          |          |          | No. of States |
|-----------------|----------|------------|--------------------|----------|----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | OR.W     | #xx:16, Rd | 7   9              | 4   rd   | IMM      |          | 2             |
| Register direct | OR.W     | Rs, Rd     | 6   4              | rs   rd  |          |          | 1             |

## Notes

**2.2.47 (3) OR (L)****OR (inclusive OR logical)****Logical OR****Operation**

ERd ∨ (EAs) → ERd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

OR.L &lt;EAs&gt;, ERd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Longword

**Description**

This instruction ORs the source operand with the contents of a 32-bit register ERd (destination operand) and stores the result in the 32-bit register ERd.

**Available Registers**

ERd: ER0 to ER7

ERs: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands    | Instruction Format |          |          |          |          |          | No. of States |     |   |     |   |
|-----------------|----------|-------------|--------------------|----------|----------|----------|----------|----------|---------------|-----|---|-----|---|
|                 |          |             | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte |               |     |   |     |   |
| Immediate       | OR.L     | #xx:32, ERd | 7                  | A        | 4        | 0        | IMM      |          |               | 3   |   |     |   |
| Register direct | OR.L     | ERs, ERd    | 0                  | 1        | F        | 0        | 6        | 4        | 0             | ers | 0 | erd | 2 |

**Notes**

## 2.2.48 (1) ORC

ORC (inclusive OR Control register)

Logical OR with CCR

**Operation**CCR  $\vee$  #IMM  $\rightarrow$  CCR**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| ↑ | ↑  | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

ORC #xx:8, CCR

- I: Stores the corresponding bit of the result.  
 UI: Stores the corresponding bit of the result.  
 H: Stores the corresponding bit of the result.  
 U: Stores the corresponding bit of the result.  
 N: Stores the corresponding bit of the result.  
 Z: Stores the corresponding bit of the result.  
 V: Stores the corresponding bit of the result.  
 C: Stores the corresponding bit of the result.

**Operand Size**

Byte

**Description**

This instruction ORs the contents of the condition-code register (CCR) with immediate data and stores the result in the condition-code register. No interrupt requests, including NMI, are accepted immediately after execution of this instruction.

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands   | Instruction Format |          |          |          | No. of States |
|-----------------|----------|------------|--------------------|----------|----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | ORC      | #xx:8, CCR | 0 ..... 4          | IMM      |          |          | 1             |

**Notes**

## 2.2.48 (2) ORC

ORC (inclusive OR Control register)

Logical OR with EXR

**Operation**

EXR ∨ #IMM → EXR

**Condition Code**

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

**Assembly-Language Format**

ORC #xx:8, EXR

H: Stores the corresponding bit of the result.

N: Stores the corresponding bit of the result.

Z: Stores the corresponding bit of the result.

V: Stores the corresponding bit of the result.

C: Stores the corresponding bit of the result.

**Operand Size**

Byte

**Description**

This instruction ORs the contents of the extended control register (EXR) with immediate data and stores the result in the extended control register. No interrupt requests, including NMI, are accepted for three states after execution of this instruction.

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands   | Instruction Format |           |           |          | No. of States |
|-----------------|----------|------------|--------------------|-----------|-----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte  | 3rd byte  | 4th byte |               |
| Immediate       | ORC      | #xx:8, EXR | 0 ..... 1          | 4 ..... 1 | 0 ..... 4 | IMM      | 2             |

**Notes**

**2.2.49 (1) POP (W)****POP (POP data)****Pop Data from Stack****Operation**

@SP+ → Rn

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

POP.W Rn

- H: Previous value remains unchanged.  
 N: Set to 1 if the transferred data is negative; otherwise cleared to 0.  
 Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

**Operand Size**

Word

**Description**

This instruction restores data from the stack to a 16-bit general register Rn, tests the restored data, and sets condition-code flags according to the result.

**Available Registers**

Rn: R0 to R7, E0 to E7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| —               | POP.W    | Rn       | 6                  | D        | 7        | rn       | 3             |

**Notes**

POP.W Rn is identical to MOV.W @SP+, Rn.

**2.2.49 (2) POP (L)****POP (POP data)****Pop Data from Stack****Operation**

@SP+ → ERn

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

POP.L ERn

H: Previous value remains unchanged.

N: Set to 1 if the transferred data is negative; otherwise cleared to 0.

Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Longword

**Description**

This instruction restores data from the stack to a 32-bit general register ERn, tests the restored data, and sets condition-code flags according to the result.

**Available Registers**

ERn: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |   |          |   |          |   |          |   | No. of States |   |
|-----------------|----------|----------|--------------------|---|----------|---|----------|---|----------|---|---------------|---|
|                 |          |          | 1st byte           |   | 2nd byte |   | 3rd byte |   | 4th byte |   |               |   |
| —               | POP.L    | ERn      | 0                  | 1 | 0        | 0 | 6        | D | 7        | 0 | ern           | 5 |

**Notes**

POP.L ERn is identical to MOV.L @SP+, ERn.



**2.2.50 (1) PUSH (W)****PUSH (PUSH data)****Push Data on Stack****Operation**

Rn → @-SP

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

PUSH.W Rn

- H: Previous value remains unchanged.  
 N: Set to 1 if the transferred data is negative; otherwise cleared to 0.  
 Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

**Operand Size**

Word

**Description**

This instruction saves data from a 16-bit register Rn onto the stack, tests the saved data, and sets condition-code flags according to the result.

**Available Registers**

Rn: R0 to R7, E0 to E7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |             |          |          | No. of States |
|-----------------|----------|----------|--------------------|-------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte    | 3rd byte | 4th byte |               |
| —               | PUSH.W   | Rn       | 6<br>⋮<br>D        | F<br>⋮<br>m |          |          | 3             |

**Notes**

1. PUSH.W Rn is identical to MOV.W Rn, @-SP.
2. When PUSH.W R7 or PUSH.W E7 is executed, the value saved on the stack is the R7 or E7 value after effective address calculation (after ER7 is decremented by 2).

**2.2.50 (2) PUSH (L)****PUSH (PUSH data)****Push Data on Stack****Operation**

ERn → @-SP

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

PUSH.L ERn

H: Previous value remains unchanged.

N: Set to 1 if the transferred data is negative; otherwise cleared to 0.

Z: Set to 1 if the transferred data is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Longword

**Description**

This instruction pushes data from a 32-bit register ERn onto the stack, tests the saved data, and sets condition-code flags according to the result.

**Available Registers**

ERn: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| —               | PUSH.L   | ERn      | 0 1                | 0 0      | 6 D      | F 0ern   | 5             |

**Notes**

1. PUSH.L ERn is identical to MOV.L ERn, @-SP.
2. When PUSH.L ER7 is executed, the value saved on the stack is the ER7 value after effective address calculation (after ER7 is decremented by 4).

## 2.2.51 (1) ROTL (B)

## ROTL (ROTate Left)

Rotate

## Operation

Rd (left rotation) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTL.B Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

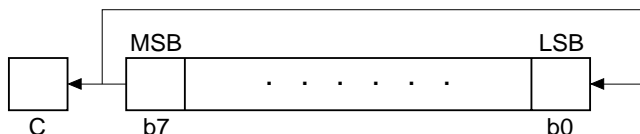
C: Receives the previous value in bit 7.

## Operand Size

Byte

## Description

This instruction rotates the bits in an 8-bit register Rd (destination operand) one bit to the left. The most significant bit (bit 7) is rotated to the least significant bit (bit 0), and also copied to the carry flag.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ROTL.B   | Rd       | 1                  | 2        | 8        | rd       | 1             |

## Notes

## 2.2.51 (2) ROTL (B)

## ROTL (ROTate Left)

Rotate

## Operation

Rd (left rotation) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTL.B #2, Rd

## Operand Size

Byte

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

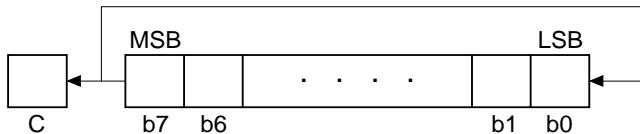
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 6.

## Description

This instruction rotates the bits in an 8-bit register Rd (destination operand) two bits to the left. The most significant two bits (bits 7 and 6) are rotated to the least significant two bits (bits 1 and 0), and bit 6 is also copied to the carry flag.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |            |          |          | No. of States |
|-----------------|----------|----------|--------------------|------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Register direct | ROTL.B   | #2, Rd   | 1 ..... 2          | C ..... rd |          |          | 1             |

## Notes

## 2.2.51 (3) ROTL (W)

## ROTL (ROTate Left)

Rotate

## Operation

Rd (left rotation) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTL.W Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

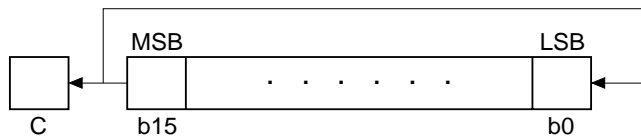
C: Receives the previous value in bit 15.

## Operand Size

Word

## Description

This instruction rotates the bits in a 16-bit register Rd (destination operand) one bit to the left. The most significant bit (bit 15) is rotated to the least significant bit (bit 0), and also copied to the carry flag.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ROTL.W   | Rd       | 1                  | 2        | 9        | rd       | 1             |

## Notes

## 2.2.51 (4) ROTL (W)

## ROTL (ROTate Left)

Rotate

## Operation

Rd (left rotation) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTL.W #2, Rd

## Operand Size

Word

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

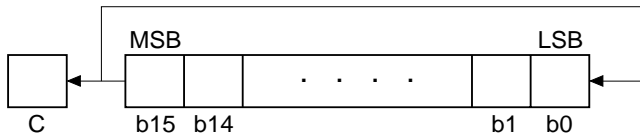
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 14.

## Description

This instruction rotates the bits in a 16-bit register Rd (destination operand) two bits to the left. The most significant two bits (bits 15 and 14) are rotated to the least significant two bits (bits 1 and 0), and bit 14 is also copied to the carry flag.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |            |          |          | No. of States |
|-----------------|----------|----------|--------------------|------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Register direct | ROTL.W   | #2, Rd   | 1 ..... 2          | D ..... rd |          |          | 1             |

## Notes

## 2.2.51 (5) ROTL (L)

## ROTL (ROTate Left)

Rotate

## Operation

ERd (left rotation) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTL.L ERd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

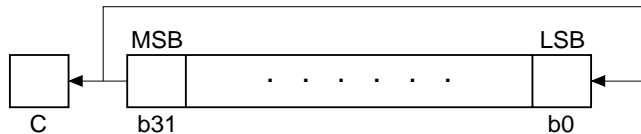
C: Receives the previous value in bit 31.

## Operand Size

Longword

## Description

This instruction rotates the bits in a 32-bit register ERd (destination operand) one bit to the left. The most significant bit (bit 31) is rotated to the least significant bit (bit 0), and also copied to the carry flag.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |           |          | No. of States |
|-----------------|----------|----------|--------------------|----------|-----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte  | 4th byte |               |
| Register direct | ROTL.L   | ERd      | 1                  | 2        | B 0   erd |          | 1             |

## Notes

## 2.2.51 (6) ROTL (L)

## ROTL (ROTate Left)

Rotate

## Operation

ERd (left rotation) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTL.L #2, ERd

## Operand Size

Longword

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

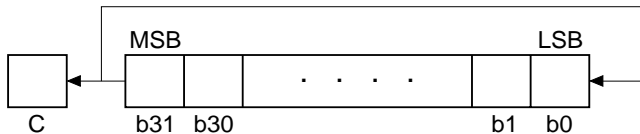
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 30.

## Description

This instruction rotates the bits in a 32-bit register ERd (destination operand) two bits to the left. The most significant two bits (bits 31 and 30) are rotated to the least significant two bits (bits 1 and 0), and bit 30 is also copied to the carry flag.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |                |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte       | 3rd byte | 4th byte |               |
| Register direct | ROTL.L   | #2, ERd  | 1<br>⋮<br>2        | F<br>⋮<br>0erd |          |          | 1             |

## Notes



## 2.2.52 (1) ROTR (B)

**ROTR (ROTate Right)****Rotate****Operation**

Rd (right rotation) → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

**Assembly-Language Format**

ROTR.B Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

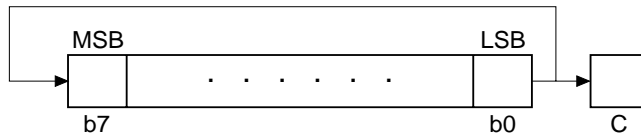
C: Receives the previous value in bit 0.

**Operand Size**

Byte

**Description**

This instruction rotates the bits in an 8-bit register Rd (destination operand) one bit to the right. The least significant bit (bit 0) is rotated to the most significant bit (bit 7), and also copied to the carry flag.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ROTR.B   | Rd       | 1 : 3              | 8 : rd   |          |          | 1             |

**Notes**

## 2.2.52 (2) ROTR (B)

## ROTR (ROTate Right)

Rotate

## Operation

Rd (right rotation) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTR.B #2, Rd

## Operand Size

Byte

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

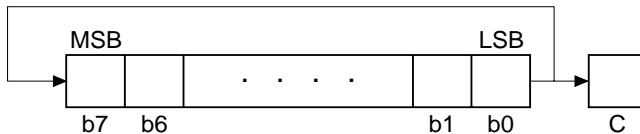
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 1.

## Description

This instruction rotates the bits in an 8-bit register Rd (destination operand) two bits to the right. The least significant two bits (bits 1 and 0) are rotated to the most significant two bits (bits 7 and 6), and bit 1 is also copied to the carry flag.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |            |          |          | No. of States |
|-----------------|----------|----------|--------------------|------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Register direct | ROTR.B   | #2, Rd   | 1 ..... 3          | C ..... rd |          |          | 1             |

## Notes

## 2.2.52 (3) ROTR (W)

**ROTR (ROTate Right)****Rotate****Operation**

Rd (right rotation) → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

**Assembly-Language Format**

ROTR.W Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

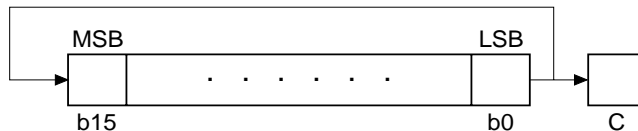
C: Receives the previous value in bit 0.

**Operand Size**

Word

**Description**

This instruction rotates the bits in a 16-bit register Rd (destination operand) one bit to the right. The least significant bit (bit 0) is rotated to the most significant bit (bit 15), and also copied to the carry flag.

**Available Registers**

Rd: R0 to R7, E0 to E7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ROTR.W   | Rd       | 1 .. 3             | 9 .. rd  |          |          | 1             |

**Notes**

## 2.2.52 (4) ROTR (W)

## ROTR (ROTate Right)

Rotate

## Operation

Rd (right rotation) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTR.W #2, Rd

## Operand Size

Word

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

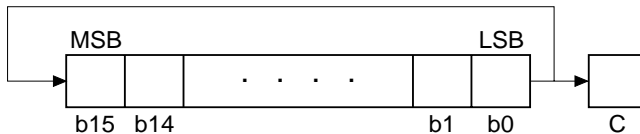
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 1.

## Description

This instruction rotates the bits in a 16-bit register Rd (destination operand) two bits to the right. The least significant two bits (bits 1 and 0) are rotated to the most significant two bits (bits 15 and 14), and bit 1 is also copied to the carry flag.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |            |          |          | No. of States |
|-----------------|----------|----------|--------------------|------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Register direct | ROTR.W   | #2, Rd   | 1 ..... 3          | D ..... rd |          |          | 1             |

## Notes

## 2.2.52 (5) ROTR (L)

**ROTR (ROTate Right)****Rotate****Operation**

ERd (right rotation) → ERd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

**Assembly-Language Format**

ROTR.L ERd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

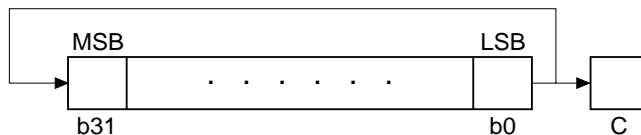
C: Receives the previous value in bit 0.

**Operand Size**

Longword

**Description**

This instruction rotates the bits in a 32-bit register ERd (destination operand) one bit to the right. The least significant bit (bit 0) is rotated to the most significant bit (bit 31), and also copied to the carry flag.

**Available Registers**

ERd: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ROTR.L   | ERd      | 1                  | 3        | B 0:erd  |          | 1             |

**Notes**

## 2.2.52 (6) ROTR (L)

## ROTR (ROTate Right)

Rotate

## Operation

ERd (right rotation) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTR.L #2, ERd

## Operand Size

Longword

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

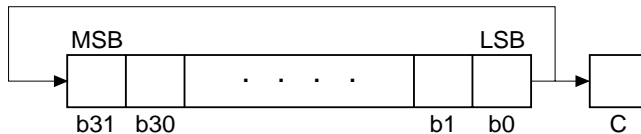
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 1.

## Description

This instruction rotates the bits in a 32-bit register ERd (destination operand) two bits to the right. The least significant two bits (bits 1 and 0) are rotated to the most significant two bits (bits 31 and 30), and bit 1 is also copied to the carry flag.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |             |          |          | No. of States |
|-----------------|----------|----------|--------------------|-------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte    | 3rd byte | 4th byte |               |
| Register direct | ROTR.L   | #2, ERd  | 1<br>⋮<br>3        | F<br>⋮<br>0 | erd      |          | 1             |

## Notes

## 2.2.53 (1) ROTXL (B)

## ROTXL (ROTate with eXtend carry Left)

Rotate through Carry

## Operation

Rd (left rotation through carry flag) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXL.B Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

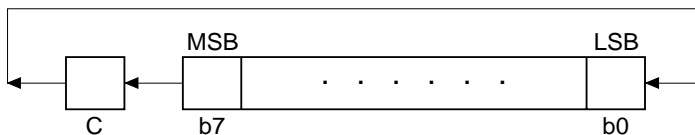
C: Receives the previous value in bit 7.

## Operand Size

Byte

## Description

This instruction rotates the bits in an 8-bit register Rd (destination operand) one bit to the left through the carry flag. The carry flag is rotated into the least significant bit (bit 0). The most significant bit (bit 7) rotates into the carry flag.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ROTXL.B  | Rd       | 1                  | 2        | 0        | rd       | 1             |

## Notes

## 2.2.53 (2) ROTXL (B)

## ROTXL (ROTate with eXtend carry Left)

Rotate through Carry

## Operation

Rd (left rotation through carry flag) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXL .B #2, Rd

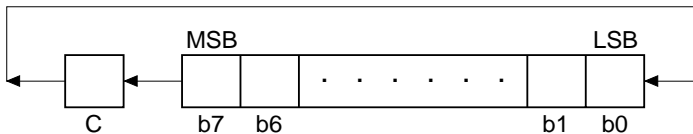
## Operand Size

Byte

- H: Previous value remains unchanged.  
 N: Set to 1 if the result is negative; otherwise cleared to 0.  
 Z: Set to 1 if the result is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Receives the previous value in bit 6.

## Description

This instruction rotates the bits in an 8-bit register Rd (destination operand) two bits to the left through the carry flag. The carry flag rotates into bit 1, bit 7 rotates into bit 0, and bit 6 rotates into the carry flag.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ROTXL.B  | #2, Rd   | 1 .. 2             | 4 .. rd  |          |          | 1             |

## Notes



## 2.2.53 (3) ROTXL (W)

## ROTXL (ROTate with eXtend carry Left)

Rotate through Carry

## Operation

Rd (left rotation through carry flag) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXL.W Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

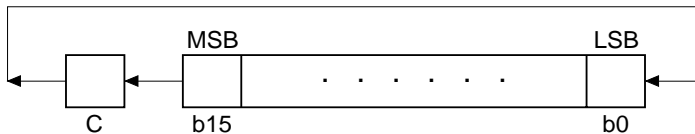
C: Receives the previous value in bit 15.

## Operand Size

Word

## Description

This instruction rotates the bits in a 16-bit register Rd (destination operand) one bit to the left through the carry flag. The carry flag is rotated into the least significant bit (bit 0). The most significant bit (bit 15) rotates into the carry flag.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ROTXL.W  | Rd       | 1                  | 2        | 1        | rd       | 1             |

## Notes

## 2.2.53 (4) ROTXL (W)

## ROTXL (ROTate with eXtend carry Left)

Rotate through Carry

## Operation

Rd (left rotation through carry flag) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXL.W #2, Rd

## Operand Size

Word

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

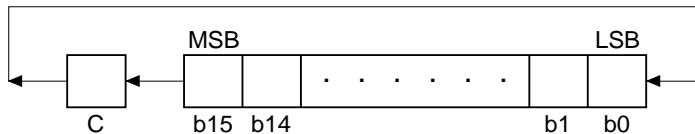
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 14.

## Description

This instruction rotates the bits in a 16-bit register Rd (destination operand) two bits to the left through the carry flag. The carry flag rotates into bit 1, bit 15 rotates into bit 0, and bit 14 rotates into the carry flag.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |            |          |          | No. of States |
|-----------------|----------|----------|--------------------|------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Register direct | ROTXL.W  | #2, Rd   | 1 ..... 2          | 5 ..... rd |          |          | 1             |

## Notes

## 2.2.53 (5) ROTXL (L)

ROTXL (ROTate with eXtend carry Left)

Rotate through Carry

## Operation

ERd (left rotation through carry flag) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXL.L ERd

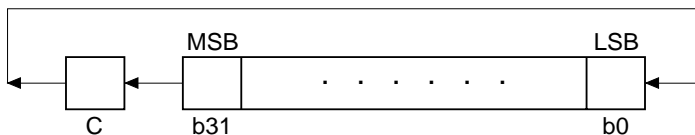
- H: Previous value remains unchanged.  
 N: Set to 1 if the result is negative; otherwise cleared to 0.  
 Z: Set to 1 if the result is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Receives the previous value in bit 31.

## Operand Size

Longword

## Description

This instruction rotates the bits in a 32-bit register ERd (destination operand) one bit to the left through the carry flag. The carry flag is rotated into the least significant bit (bit 0). The most significant bit (bit 31) rotates into the carry flag.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ROTXL.L  | ERd      | 1                  | 2        | 3        | 0:erd    | 1             |

## Notes

## 2.2.53 (6) ROTXL (L)

## ROTXL (ROTate with eXtend carry Left)

Rotate through Carry

## Operation

ERd (left rotation through carry flag) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXL.L #2, ERd

## Operand Size

Longword

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

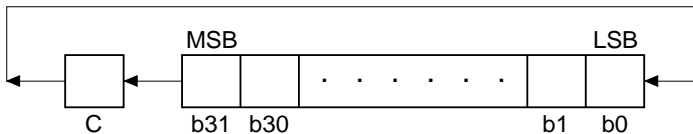
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 30.

## Description

This instruction rotates the bits in a 32-bit register ERd (destination operand) two bits to the left through the carry flag. The carry flag rotates into bit 1, bit 31 rotates into bit 0, and bit 30 rotates into the carry flag.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ROTXL.L  | #2, ERd  | 1                  | 2        | 7        | 0:erd    | 1             |

## Notes

## 2.2.54 (1) ROTXR (B)

## ROTXR (ROTate with eXtend carry Right)

Rotate through Carry

## Operation

Rd (right rotation through carry flag) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXR.B Rd

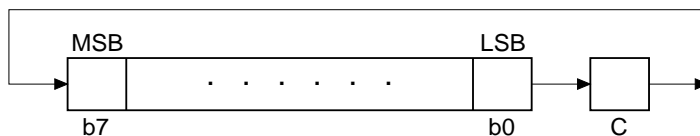
- H: Previous value remains unchanged.  
 N: Set to 1 if the result is negative; otherwise cleared to 0.  
 Z: Set to 1 if the result is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Receives the previous value in bit 0.

## Operand Size

Byte

## Description

This instruction rotates the bits in an 8-bit register Rd (destination operand) one bit to the right through the carry flag. The carry flag is rotated into the most significant bit (bit 7). The least significant bit (bit 0) rotates into the carry flag.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |            |          |          | No. of States |
|-----------------|----------|----------|--------------------|------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Register direct | ROTXR.B  | Rd       | 1 ..... 3          | 0 ..... rd |          |          | 1             |

## Notes

## 2.2.54 (2) ROTXR (B)

## ROTXR (ROTate with eXtend carry Right)

Rotate through Carry

## Operation

Rd (right rotation through carry flag) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXR.B #2, Rd

## Operand Size

Byte

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 1.

## Description

This instruction rotates the bits in an 8-bit register Rd (destination operand) two bits to the right through the carry flag. The carry flag rotates into bit 6, bit 0 rotates into bit 7, and bit 1 rotates into the carry flag.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |            |          |          | No. of States |
|-----------------|----------|----------|--------------------|------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Register direct | ROTXR.B  | #2, Rd   | 1 ..... 3          | 4 ..... rd |          |          | 1             |

## Notes

## 2.2.54 (3) ROTXR (W)

## ROTXR (ROTate with eXtend carry Right)

## Rotate through Carry

## Operation

Rd (right rotation through carry flag) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXR.W Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

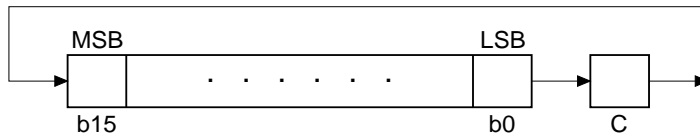
C: Receives the previous value in bit 0.

## Operand Size

Word

## Description

This instruction rotates the bits in a 16-bit register Rd (destination operand) one bit to the right through the carry flag. The carry flag is rotated into the most significant bit (bit 15). The least significant bit (bit 0) rotates into the carry flag.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |            |          |          | No. of States |
|-----------------|----------|----------|--------------------|------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Register direct | ROTXR.W  | Rd       | 1 ..... 3          | 1 ..... rd |          |          | 1             |

## Notes

## 2.2.54 (4) ROTXR (W)

## ROTXR (ROtate with eXtend carry Right)

Rotate through Carry

## Operation

Rd (right rotation through carry flag) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXR.W #2, Rd

## Operand Size

Word

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

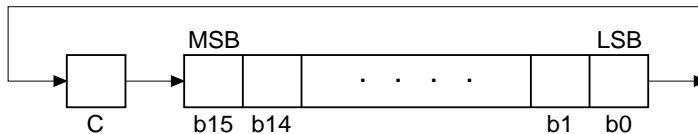
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 1.

## Description

This instruction rotates the bits in a 16-bit register Rd (destination operand) two bits to the right through the carry flag. The carry flag rotates into bit 14, bit 0 rotates into bit 15, and bit 1 rotates into the carry flag.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |            |          |          | No. of States |
|-----------------|----------|----------|--------------------|------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte   | 3rd byte | 4th byte |               |
| Register direct | ROTXR.W  | #2, Rd   | 1 ..... 3          | 5 ..... rd |          |          | 1             |

## Notes



## 2.2.54 (5) ROTXR (L)

## ROTXR (ROTate with eXtend carry Right)

Rotate through Carry

## Operation

ERd (right rotation through carry flag) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXR.L ERd

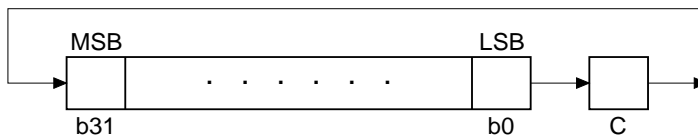
- H: Previous value remains unchanged.  
 N: Set to 1 if the result is negative; otherwise cleared to 0.  
 Z: Set to 1 if the result is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Receives the previous value in bit 0.

## Operand Size

Longword

## Description

This instruction rotates the bits in a 32-bit register ERd (destination operand) one bit to the right through the carry flag. The carry flag is rotated into the most significant bit (bit 31). The least significant bit (bit 0) rotates into the carry flag.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | ROTXR.L  | ERd      | 1                  | 3        | 3        | 0        | 1             |

## Notes

## 2.2.54 (6) ROTXR (L)

## ROTXR (ROTate with eXtend carry Right)

Rotate through Carry

## Operation

ERd (right rotation through carry flag) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

ROTXR.L #2, ERd

## Operand Size

Longword

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

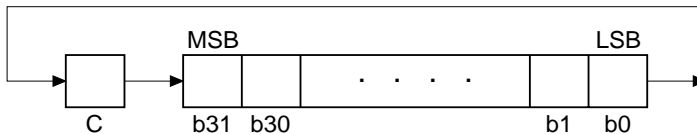
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 1.

## Description

This instruction rotates the bits in a 32-bit register ERd (destination operand) two bits to the right through the carry flag. The carry flag rotates into bit 30, bit 0 rotates into bit 31, and bit 1 rotates into the carry flag.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |              |          |          | No. of States |
|-----------------|----------|----------|--------------------|--------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte     | 3rd byte | 4th byte |               |
| Register direct | ROTXR.L  | #2, ERd  | 1 .. 3             | 7 .. 0   erd |          |          | 1             |

## Notes

## 2.2.55 RTE

**RTE (ReTurn from Exception)****Return from Exception Handling****Operation**

- When EXR is invalid  
@SP+ → CCR  
@SP+ → PC
- When EXR is valid  
@SP+ → EXR  
@SP+ → CCR  
@SP+ → PC

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| ↕ | ↕  | ↕ | ↕ | ↕ | ↕ | ↕ | ↕ |

- I: Restored from the corresponding bit on the stack.
- UI: Restored from the corresponding bit on the stack.
- H: Restored from the corresponding bit on the stack.
- U: Restored from the corresponding bit on the stack.
- N: Restored from the corresponding bit on the stack.
- Z: Restored from the corresponding bit on the stack.
- V: Restored from the corresponding bit on the stack.
- C: Restored from the corresponding bit on the stack.

**Assembly-Language Format**

RTE

**Operand Size****Description**

This instruction returns from an exception-handling routine by restoring the EXR, condition-code register (CCR) and program counter (PC) from the stack. Program execution continues from the address restored to the program counter. The CCR and PC contents at the time of execution of this instruction are lost. If the extended control register (EXR) is valid, it is also restored (and the existing EXR contents are lost).

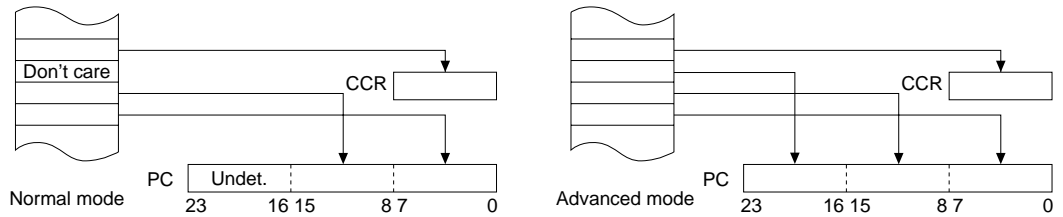
**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| —               | RTE      |          | 5    6             | 7    0   |          |          | 5*            |

Note: \* Six states when EXR is valid.

**RTE (ReTurn from Exception)****Return from Exception Handling****Notes**

The stack structure differs between normal mode and advanced mode.



## 2.2.56 RTS

## RTS (ReTurn from Subroutine)

## Return from Subroutine

## Operation

@SP+ → PC

## Condition Code

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

## Assembly-Language Format

RTS

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

## Operand Size

—

## Description

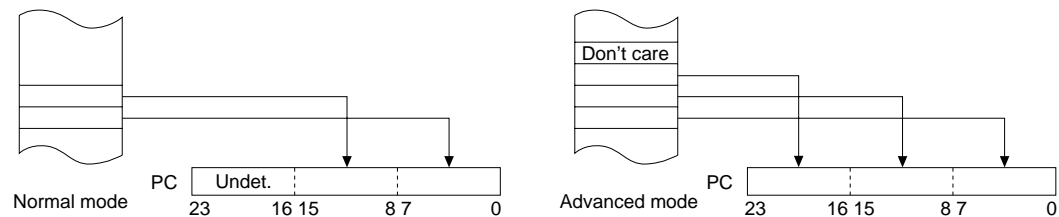
This instruction returns from a subroutine by restoring the program counter (PC) from the stack. Program execution continues from the address restored to the program counter. The PC contents at the time of execution of this instruction are lost.

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |          |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|----------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte | Normal        | Advanced |
| —               | RTS      |          | 5 4                | 7 0      |          |          | 4             | 5        |

## Notes

The stack structure and number of states required for execution differ between normal mode and advanced mode. In normal mode, only the lower 16 bits of the program counter are restored.



## 2.2.57 (1) SHAL (B)

## SHAL (SHift Arithmetic Left)

## Shift Arithmetic

## Operation

Rd (left arithmetic shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | ↕ | ↕ |

## Assembly-Language Format

SHAL.B Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

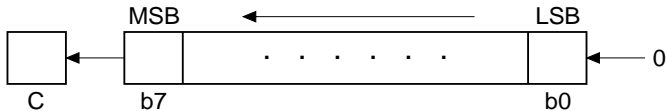
C: Receives the previous value in bit 7.

## Operand Size

Byte

## Description

This instruction shifts the bits in an 8-bit register Rd (destination operand) one bit to the left. The most significant bit (bit 7) shifts into the carry flag. The least significant bit (bit 0) is cleared to 0.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAL.B   | Rd       | 1 0                | 8 rd     |          |          | 1             |

## Notes

The SHAL instruction differs from the SHLL instruction in its effect on the overflow flag.

## 2.2.57 (2) SHAL (B)

## SHAL (SHift Arithmetic Left)

## Shift Arithmetic

## Operation

Rd (left arithmetic shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | ↕ | ↕ |

## Assembly-Language Format

SHAL.B #2, Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

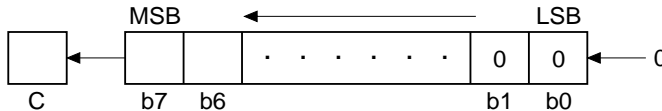
C: Receives the previous value in bit 6.

## Operand Size

Byte

## Description

This instruction shifts the bits in an 8-bit register Rd (destination operand) two bits to the left. Bit 6 shifts into the carry flag. Bits 0 and 1 are cleared to 0.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAL.B   | #2, Rd   | 1 0                | C rd     |          |          | 1             |

## Notes

The SHAL instruction differs from the SHLL instruction in its effect on the overflow flag.

## 2.2.57 (3) SHAL (W)

## SHAL (SHift Arithmetic Left)

## Shift Arithmetic

## Operation

Rd (left arithmetic shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | ↕ | ↕ |

## Assembly-Language Format

SHAL.W Rd

## Operand Size

Word

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

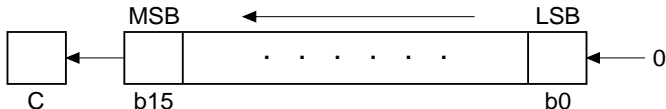
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Receives the previous value in bit 15.

## Description

This instruction shifts the bits in a 16-bit register Rd (destination operand) one bit to the left. The most significant bit (bit 15) shifts into the carry flag. The least significant bit (bit 0) is cleared to 0.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAL.W   | Rd       | 1 0                | 9 rd     |          |          | 1             |

## Notes

The SHAL instruction differs from the SHLL instruction in its effect on the overflow flag.



## 2.2.57 (4) SHAL (W)

## SHAL (SHift Arithmetic Left)

## Shift Arithmetic

## Operation

Rd (left arithmetic shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | ↕ | ↕ |

## Assembly-Language Format

SHAL.W #2, Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

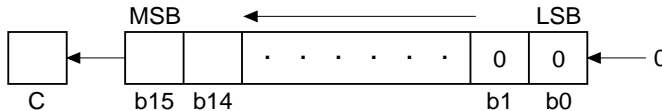
C: Receives the previous value in bit 14.

## Operand Size

Word

## Description

This instruction shifts the bits in a 16-bit register Rd (destination operand) two bits to the left. Bit 14 shifts into the carry flag. Bits 0 and 1 are cleared to 0.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAL.W   | #2, Rd   | 1 0                | D rd     |          |          | 1             |

## Notes

The SHAL instruction differs from the SHLL instruction in its effect on the overflow flag.

## 2.2.57 (5) SHAL (L)

## SHAL (SHift Arithmetic Left)

## Shift Arithmetic

## Operation

ERd (left arithmetic shift) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | ↕ | ↕ |

## Assembly-Language Format

SHAL.L ERd

## Operand Size

Longword

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

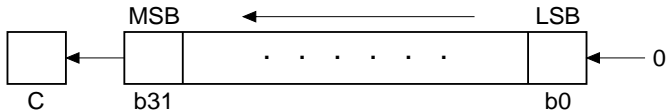
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Receives the previous value in bit 31.

## Description

This instruction shifts the bits in a 32-bit register ERd (destination operand) one bit to the left. The most significant bit (bit 31) shifts into the carry flag. The least significant bit (bit 0) is cleared to 0.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAL.L   | ERd      | 1 0                | B 0      | erd      |          | 1             |

## Notes

The SHAL instruction differs from the SHLL instruction in its effect on the overflow flag.

## 2.2.57 (6) SHAL (L)

## SHAL (SHift Arithmetic Left)

## Shift Arithmetic

## Operation

ERd (left arithmetic shift) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | ↕ | ↕ |

## Assembly-Language Format

SHAL.L #2, ERd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

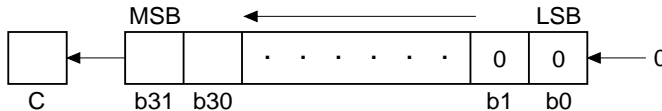
C: Receives the previous value in bit 30.

## Operand Size

Longword

## Description

This instruction shifts the bits in a 32-bit register ERd (destination operand) two bits to the left. Bit 30 shifts into the carry flag. Bits 0 and 1 are cleared to 0.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAL.L   | #2, ERd  | 1 0                | F 0      | erd      |          | 1             |

## Notes

The SHAL instruction differs from the SHLL instruction in its effect on the overflow flag.

## 2.2.58 (1) SHAR (B)

## SHAR (SHift Arithmetic Right)

## Shift Arithmetic

## Operation

Rd (right arithmetic shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

SHAR.B Rd

## Operand Size

Byte

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

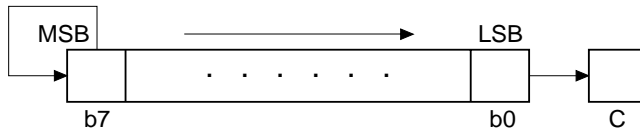
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 0.

## Description

This instruction shifts the bits in an 8-bit register Rd (destination operand) one bit to the right. Bit 0 shifts into the carry flag. Bit 7 shifts into itself. Since bit 7 remains unaltered, the sign does not change.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAR.B   | Rd       | 1 1                | 8 rd     |          |          | 1             |

## Notes

## 2.2.58 (2) SHAR (B)

## SHAR (SHift Arithmetic Right)

## Shift Arithmetic

## Operation

Rd (right arithmetic shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

SHAR.B #2, Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

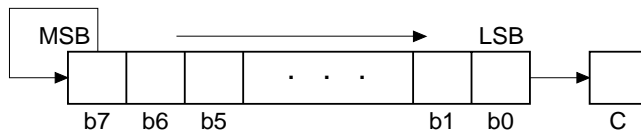
C: Receives the previous value in bit 1.

## Operand Size

Byte

## Description

This instruction shifts the bits in an 8-bit register Rd (destination operand) two bits to the right. Bit 1 shifts into the carry flag. Bits 7 and 6 receive the previous value of bit 7. Since bit 7 remains unaltered, the sign does not change.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAR.B   | #2, Rd   | 1 ‖ 1              | C ‖ rd   |          |          | 1             |

## Notes

## 2.2.58 (3) SHAR (W)

## SHAR (SHift Arithmetic Right)

## Shift Arithmetic

## Operation

Rd (right arithmetic shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

SHAR.W Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

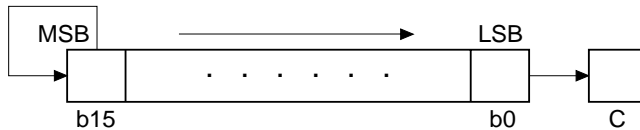
C: Receives the previous value in bit 0.

## Operand Size

Word

## Description

This instruction shifts the bits in a 16-bit register Rd (destination operand) one bit to the right. Bit 0 shifts into the carry flag. Bit 15 shifts into itself. Since bit 15 remains unaltered, the sign does not change.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAR.W   | Rd       | 1 1                | 9 rd     |          |          | 1             |

## Notes

## 2.2.58 (4) SHAR (W)

## SHAR (SHift Arithmetic Right)

## Shift Arithmetic

## Operation

Rd (right arithmetic shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

SHAR.W #2, Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

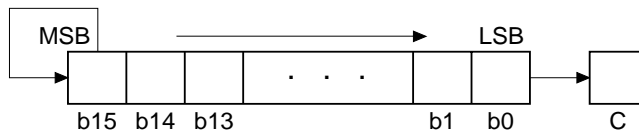
C: Receives the previous value in bit 1.

## Operand Size

Word

## Description

This instruction shifts the bits in a 16-bit register Rd (destination operand) two bits to the right. Bit 1 shifts into the carry flag. Bits 15 and 14 receive the previous value of bit 15. Since bit 15 remains unaltered, the sign does not change.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAR.W   | #2, Rd   | 1 ‖ 1              | D ‖ rd   |          |          | 1             |

## Notes

## 2.2.58 (5) SHAR (L)

## SHAR (SHift Arithmetic Right)

## Shift Arithmetic

## Operation

ERd (right arithmetic shift) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

SHAR.L ERd

## Operand Size

Longword

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

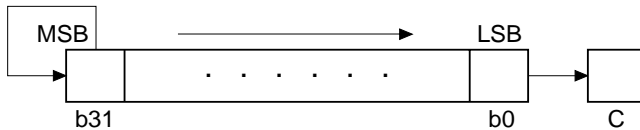
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 0.

## Description

This instruction shifts the bits in a 32-bit register ERd (destination operand) one bit to the right. Bit 0 shifts into the carry flag. Bit 31 shifts into itself. Since bit 31 remains unaltered, the sign does not change.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAR.L   | ERd      | 1                  | 1        | B 0 ERd  |          | 1             |

## Notes



## 2.2.58 (6) SHAR (L)

## SHAR (SHift Arithmetic Right)

## Shift Arithmetic

## Operation

ERd (right arithmetic shift) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

SHAR.L #2, ERd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

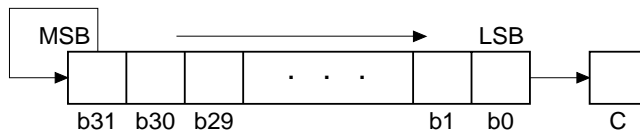
C: Receives the previous value in bit 1.

## Operand Size

Longword

## Description

This instruction shifts the bits in a 32-bit register ERd (destination operand) two bits to the right. Bit 1 shifts into the carry flag. Bits 31 and 30 receive the previous value of bit 31. Since bit 31 remains unaltered, the sign does not change.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHAR.L   | #2, ERd  | 1 1                | F 0      | erd      |          | 1             |

## Notes

**2.2.59 (1) SHLL (B)****SHLL (SHift Logical Left)****Shift Logical****Operation**

Rd (left logical shift) → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

**Assembly-Language Format**

SHLL.B Rd

**Operand Size**

Byte

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

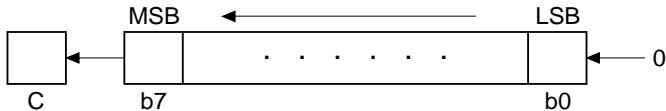
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 7.

**Description**

This instruction shifts the bits in an 8-bit register Rd (destination operand) one bit to the left. The most significant bit (bit 7) shifts into the carry flag. The least significant bit (bit 0) is cleared to 0.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHLL.B   | Rd       | 1 0                | 0 rd     |          |          | 1             |

**Notes**

The SHLL instruction differs from the SHAL instruction in its effect on the overflow flag.

## 2.2.59 (2) SHLL (B)

## SHLL (SHift Logical Left)

Shift Logical

## Operation

Rd (left logical shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

SHLL.B #2, Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

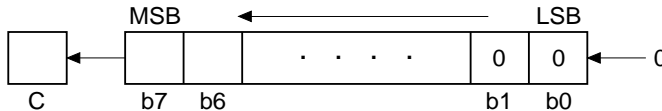
C: Receives the previous value in bit 6.

## Operand Size

Byte

## Description

This instruction shifts the bits in an 8-bit register Rd (destination operand) two bits to the left. Bit 6 shifts into the carry flag. Bits 0 and 1 are cleared to 0.



## Available Registers

Rd: R0L to R7L, R0H to R7H

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHLL.B   | #2, Rd   | 1     0            | 4     rd |          |          | 1             |

## Notes

The SHLL instruction differs from the SHAL instruction in its effect on the overflow flag.

## 2.2.59 (3) SHLL (W)

## SHLL (SHift Logical Left)

Shift Logical

## Operation

Rd (left logical shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

SHLL.W Rd

## Operand Size

Word

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

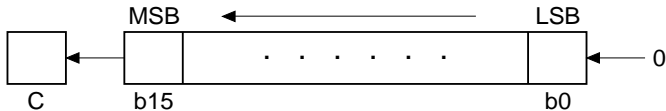
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 15.

## Description

This instruction shifts the bits in a 16-bit register Rd (destination operand) one bit to the left. The most significant bit (bit 15) shifts into the carry flag. The least significant bit (bit 0) is cleared to 0.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHLL.W   | Rd       | 1 0                | 1 rd     |          |          | 1             |

## Notes

The SHLL instruction differs from the SHAL instruction in its effect on the overflow flag.

## 2.2.59 (4) SHLL (W)

## SHLL (SHift Logical Left)

Shift Logical

## Operation

Rd (left logical shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

SHLL.W #2, Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

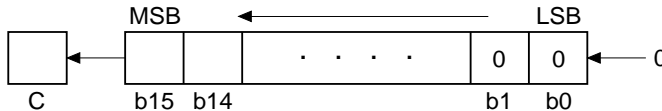
C: Receives the previous value in bit 14.

## Operand Size

Word

## Description

This instruction shifts the bits in a 16-bit register Rd (destination operand) two bits to the left. Bit 14 shifts into the carry flag. Bits 0 and 1 are cleared to 0.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHLL.W   | #2, Rd   | 1 0                | 5 rd     |          |          | 1             |

## Notes

The SHLL instruction differs from the SHAL instruction in its effect on the overflow flag.

## 2.2.59 (5) SHLL (L)

## SHLL (SHift Logical Left)

Shift Logical

## Operation

ERd (left logical shift) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

SHLL.L ERd

## Operand Size

Longword

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

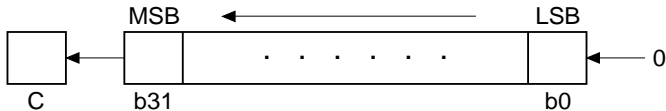
Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Receives the previous value in bit 31.

## Description

This instruction shifts the bits in a 32-bit register ERd (destination operand) one bit to the left. The most significant bit (bit 31) shifts into the carry flag. The least significant bit (bit 0) is cleared to 0.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHLL.L   | ERd      | 1 0                | 3 0 ERd  |          |          | 1             |

## Notes

The SHLL instruction differs from the SHAL instruction in its effect on the overflow flag.

## 2.2.59 (6) SHLL (L)

## SHLL (SHift Logical Left)

Shift Logical

## Operation

ERd (left logical shift) → ERd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | ↕ |

## Assembly-Language Format

SHLL.L #2, ERd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

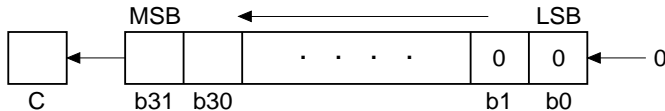
C: Receives the previous value in bit 30.

## Operand Size

Longword

## Description

This instruction shifts the bits in a 32-bit register ERd (destination operand) two bits to the left. Bit 30 shifts into the carry flag. Bits 0 and 1 are cleared to 0.



## Available Registers

ERd: ER0 to ER7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |             |          |          | No. of States |
|-----------------|----------|----------|--------------------|-------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte    | 3rd byte | 4th byte |               |
| Register direct | SHLL.L   | #2, ERd  | 1 0                | 7 0     erd |          |          | 1             |

## Notes

The SHLL instruction differs from the SHAL instruction in its effect on the overflow flag.

**2.2.60 (1) SHLR (B)****SHLR (SHift Logical Right)****Shift Logical****Operation**

Rd (right logical shift) → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | 0 | ↕ | 0 | ↕ |

**Assembly-Language Format**

SHLR.B Rd

H: Previous value remains unchanged.

N: Always cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

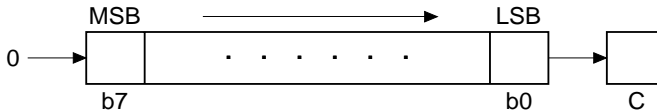
C: Receives the previous value in bit 0.

**Operand Size**

Byte

**Description**

This instruction shifts the bits in an 8-bit register Rd (destination operand) one bit to the right. The least significant bit (bit 0) shifts into the carry flag. The most significant bit (bit 7) is cleared to 0.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHLR.B   | Rd       | 1 1                | 0 rd     |          |          | 1             |

**Notes**



**2.2.60 (2) SHLR (B)****SHLR (SHift Logical Right)****Shift Logical****Operation**

Rd (right logical shift) → Rd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | 0 | ↕ | 0 | ↕ |

**Assembly-Language Format**

SHLR.B #2, Rd

H: Previous value remains unchanged.

N: Always cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

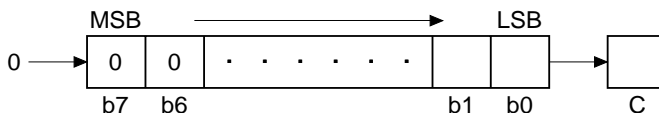
C: Receives the previous value in bit 1.

**Operand Size**

Byte

**Description**

This instruction shifts the bits in an 8-bit register Rd (destination operand) two bits to the right. Bit 1 shifts into the carry flag. Bits 7 and 6 are cleared to 0.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHLR.B   | #2, Rd   | 1 ‖ 1              | 4 ‖ rd   |          |          | 1             |

**Notes**

## 2.2.60 (3) SHLR (W)

## SHLR (SHift Logical Right)

Shift Logical

## Operation

Rd (right logical shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | 0 | ↕ | 0 | ↕ |

## Assembly-Language Format

SHLR.W Rd

H: Previous value remains unchanged.

N: Always cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

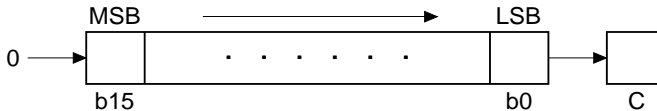
C: Receives the previous value in bit 0.

## Operand Size

Word

## Description

This instruction shifts the bits in a 16-bit register Rd (destination operand) one bit to the right. The least significant bit (bit 0) shifts into the carry flag. The most significant bit (bit 15) is cleared to 0.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHLR.W   | Rd       | 1                  | 1        | 1        | rd       | 1             |

## Notes

## 2.2.60 (4) SHLR (W)

## SHLR (SHift Logical Right)

Shift Logical

## Operation

Rd (right logical shift) → Rd

## Condition Code

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | 0 | ↑ | 0 | ↓ |

## Assembly-Language Format

SHLR.W #2, Rd

H: Previous value remains unchanged.

N: Always cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

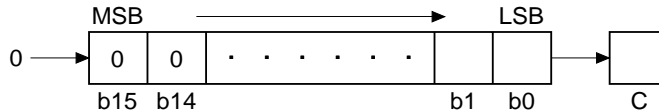
C: Receives the previous value in bit 1.

## Operand Size

Word

## Description

This instruction shifts the bits in a 16-bit register Rd (destination operand) two bits to the right. Bit 1 shifts into the carry flag. Bits 15 and 14 are cleared to 0.



## Available Registers

Rd: R0 to R7, E0 to E7

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHLR.W   | #2, Rd   | 1 ‖ 1              | 5 ‖ rd   |          |          | 1             |

## Notes

**2.2.60 (5) SHLR (L)****SHLR (SHift Logical Right)****Shift Logical****Operation**

ERd (right logical shift) → ERd

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | 0 | ↕ | 0 | ↕ |

**Assembly-Language Format**

SHLR.L ERd

H: Previous value remains unchanged.

N: Always cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

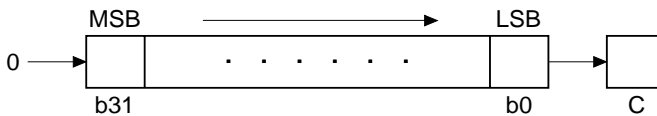
C: Receives the previous value in bit 0.

**Operand Size**

Longword

**Description**

This instruction shifts the bits in a 32-bit register ERd (destination operand) one bit to the right. The least significant bit (bit 0) shifts into the carry flag. The most significant bit (bit 31) is cleared to 0.

**Available Registers**

ERd: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SHLR.L   | ERd      | 1                  | 1        | 3        | 0   erd  | 1             |

**Notes**

**2.2.60 (6) SHLR (L)****SHLR (SHift Logical Right)****Shift Logical****Operation**

ERd (right logical shift) → ERd

**Condition Code**

|   |    |   |   |   |    |   |    |
|---|----|---|---|---|----|---|----|
| I | UI | H | U | N | Z  | V | C  |
| — | —  | — | — | 0 | ↑↓ | 0 | ↑↓ |

**Assembly-Language Format**

SHLR.L #2, ERd

H: Previous value remains unchanged.

N: Always cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

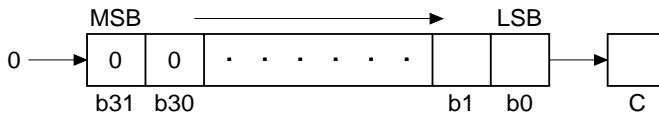
C: Receives the previous value in bit 1.

**Operand Size**

Longword

**Description**

This instruction shifts the bits in a 32-bit register ERd (destination operand) two bits to the right. Bit 1 shifts into the carry flag. Bits 31 and 30 are cleared to 0.

**Available Registers**

ERd: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |               |          |          | No. of States |
|-----------------|----------|----------|--------------------|---------------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte      | 3rd byte | 4th byte |               |
| Register direct | SHLR.L   | #2, ERd  | 1     1            | 7     0   erd |          |          | 1             |

**Notes**

**2.2.61 SLEEP****SLEEP (SLEEP)****Power-Down Mode****Operation**

Program execution state → power-down mode

**Condition Code**

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

**Assembly-Language Format**

SLEEP

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Operand Size**

—

**Description**

When the SLEEP instruction is executed, the CPU enters a power-down mode. Its internal state remains unchanged, but the CPU stops executing instructions and waits for an exception-handling request. When it receives an exception-handling request, the CPU exits the power-down mode and begins the exception-handling sequence. Interrupt requests other than NMI cannot end the power-down mode if they are masked in the CPU.

**Available Registers**

—

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |           |          |          | No. of States |
|-----------------|----------|----------|--------------------|-----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte  | 3rd byte | 4th byte |               |
| —               | SLEEP    |          | 0 ..... 1          | 8 ..... 0 |          |          | 2             |

**Notes**

For information about power-down modes, see the relevant microcontroller hardware manual.

**2.2.62 (1) STC (B)****STC (STore from Control register)****Store CCR****Operation**

CCR → Rd

**Condition Code**

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

**Assembly-Language Format**

STC .B CCR, Rd

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction copies the CCR contents to an 8-bit register Rd.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | STC.B    | CCR, Rd  | 0                  | 2        | 0        | rd       | 1             |

**Notes**

**2.2.62 (2) STC (B)****STC (STore from Control register)****Store EXR****Operation**

EXR → Rd

**Condition Code**

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

**Assembly-Language Format**

STC .B EXR, Rd

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction copies the EXR contents to an 8-bit register Rd.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | STC.B    | EXR, Rd  | 0 2                | 1 rd     |          |          | 1             |

**Notes**



**2.2.62 (3) STC (W)****STC (STore from Control register)****Store CCR****Operation**

CCR → (EAd)

**Condition Code**

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

**Assembly-Language Format**

STC .W CCR, &lt;EAd&gt;

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Operand Size**

Word

**Description**

This instruction copies the CCR contents to a destination location. Although CCR is a byte register, the destination operand is a word operand. The CCR contents are stored at the even address. Undetermined data is stored at the odd address.

**Available Registers**

ERd: ER0 to ER7

## STC (STore from Control register)

Store CCR

## Operand Format and Number of States Required for Execution

| Addressing Mode                      | Mnemonic | Operands          | Instruction Format |          |          |          |          |          |          |          |          |           | No. of States |      |  |  |   |
|--------------------------------------|----------|-------------------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|---------------|------|--|--|---|
|                                      |          |                   | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |               |      |  |  |   |
| Register indirect                    | STC.W    | CCR, @ERd         | 0                  | 1        | 4        | 0        | 6        | 9        | 1:erd    | 0        |          |           |               |      |  |  | 3 |
| Register indirect with displacement  | STC.W    | CCR, @(d:16, ERd) | 0                  | 1        | 4        | 0        | 6        | F        | 1:erd    | 0        | disp     |           |               |      |  |  | 4 |
|                                      | STC.W    | CCR, @(d:32, ERd) | 0                  | 1        | 4        | 0        | 7        | 8        | 0:erd    | 0        | 6        | A         | 0             | disp |  |  | 6 |
| Register indirect with pre-decrement | STC.W    | CCR, @--ERd       | 0                  | 1        | 4        | 0        | 6        | D        | 1:erd    | 0        |          |           |               |      |  |  | 4 |
| Absolute address                     | STC.W    | CCR, @aa:16       | 0                  | 1        | 4        | 0        | 6        | B        | 8        | 0        | abs      |           |               |      |  |  | 4 |
|                                      | STC.W    | CCR, @aa:32       | 0                  | 1        | 4        | 0        | 6        | B        | A        | 0        |          | abs       |               |      |  |  | 5 |

Notes

**2.2.62 (4) STC (W)****STC (STore from Control register)****Store EXR****Operation**

EXR → (EAd)

**Condition Code**

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

**Assembly-Language Format**

STC .W EXR, &lt;EAd&gt;

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Operand Size**

Word

**Description**

This instruction copies the EXR contents to a destination location. Although EXR is a byte register, the destination operand is a word operand. The EXR contents are stored at the even address. Undetermined data is stored at the odd address.

**Available Registers**

ERd: ER0 to ER7

## STC (STore from Control register)

Store EXR

## Operand Format and Number of States Required for Execution

| Addressing Mode                      | Mnemonic | Operands          | Instruction Format |          |          |          |          |          |          |          |          |           | No. of States |      |  |   |
|--------------------------------------|----------|-------------------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|---------------|------|--|---|
|                                      |          |                   | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |               |      |  |   |
| Register indirect                    | STC.W    | EXR, @ERd         | 0                  | 1        | 4        | 1        | 6        | 9        | 1:erd: 0 |          |          |           |               |      |  | 3 |
| Register indirect with displacement  | STC.W    | EXR, @(d:16, ERd) | 0                  | 1        | 4        | 1        | 6        | F        | 1:erd: 0 | disp     |          |           |               |      |  | 4 |
| Register indirect with pre-decrement | STC.W    | EXR, @(d:32, ERd) | 0                  | 1        | 4        | 1        | 7        | 8        | 0:erd: 0 | 6        | B        | A         | 0             | disp |  | 6 |
| Register indirect with pre-decrement | STC.W    | EXR, @-ERd        | 0                  | 1        | 4        | 1        | 6        | D        | 1:erd: 0 |          |          |           |               |      |  | 4 |
| Absolute address                     | STC.W    | EXR, @aa:16       | 0                  | 1        | 4        | 1        | 6        | B        | 8        | 0        | abs      |           |               |      |  | 4 |
|                                      | STC.W    | EXR, @aa:32       | 0                  | 1        | 4        | 1        | 6        | B        | A        | 0        |          |           | abs           |      |  | 5 |

Notes

## 2.2.63 STM

**STM (STore from Multiple registers)**

**Store Data on Stack**

### Operation

ERn (register list) → @-SP

### Condition Code

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

### Assembly-Language Format

STM.L <register list>, @-SP

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

### Operand Size

Longword

### Description

This instruction saves a group of registers specified by a register list onto the stack. The registers are saved in ascending order of register number.

Two, three, or four registers can be saved by one STM instruction. The following ranges can be specified in the register list.

Two registers: ER0–ER1, ER2–ER3, ER4–ER5, or ER6–ER7

Three registers: ER0–ER2 or ER4–ER6

Four registers: ER0–ER3 or ER4–ER7

### Available Registers

ERn: ER0 to ER7

## STM (STore from Multiple registers)

## Store Data on Stack

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands             | Instruction Format |   |          |   |          |   |          |   | No. of States |    |
|-----------------|----------|----------------------|--------------------|---|----------|---|----------|---|----------|---|---------------|----|
|                 |          |                      | 1st byte           |   | 2nd byte |   | 3rd byte |   | 4th byte |   |               |    |
| —               | STM.L    | (ERn-ERn+1),<br>@-SP | 0                  | 1 | 1        | 0 | 6        | D | F        | 0 | ern           | 7  |
| —               | STM.L    | (ERn-ERn+2),<br>@-SP | 0                  | 1 | 2        | 0 | 6        | D | F        | 0 | ern           | 9  |
| —               | STM.L    | (ERn-ERn+3),<br>@-SP | 0                  | 1 | 3        | 0 | 6        | D | F        | 0 | ern           | 11 |

## Notes

When ER7 is saved, the value after effective address calculation (after ER7 is decremented by 4) is saved on the stack.

## 2.2.64 STMAC

## STMAC (STore from MAC register)

## Store Data from MAC Register

**Operation**

MACH → ERd  
or  
MACL → ERd

**Condition Code**

| I | UI | H | U | N  | Z  | V  | C |
|---|----|---|---|----|----|----|---|
| — | —  | — | — | ↕* | ↕* | ↕* | — |

**Assembly-Language Format**

STMAC MAC register, ERd

**Operand Size**

Longword

- H: Previous value remains unchanged.  
 N: Set to 1 if a MAC instruction resulted in a negative MAC register value; otherwise cleared to 0.  
 Z: Set to 1 if a MAC instruction resulted in a zero MAC register value; otherwise cleared to 0.  
 V: Set to 1 if a MAC instruction resulted in an overflow; otherwise cleared to 0.  
 C: Previous value remains unchanged.

Note: \* Execution of this instruction copies the N, Z, and V flag values from the multiplier to the condition-code register (CCR). If the STMAC instruction is executed after a CLRMAC or LDMAC instruction with no intervening MAC instruction, the V flag will be 0 and the N and Z flags will have undetermined values.

**Description**

This instruction moves the contents of a multiply-accumulate register (MACH or MACL) to a general register. If the transfer is from MACH, the upper 22 bits transferred to the general register are a sign extension.

This instruction is supported by the H8S/2600 CPU only.

**Available Registers**

ERd: ER0 to ER7

**STMAC (STore from MAC register)****Store Data from MAC Register****Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands  | Instruction Format |          |          |          | No. of States |
|-----------------|----------|-----------|--------------------|----------|----------|----------|---------------|
|                 |          |           | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | STMAC    | MACH, ERd | 0 2                | 2 0erd   |          |          | 1*            |
| Register direct | STMAC    | MACL, ERd | 0 2                | 3 0erd   |          |          | 1*            |

Note: \* A maximum of three additional states are required for execution of this instruction within three states after execution of a MAC instruction. For example, if there is a one-state instruction (such as NOP) between the MAC instruction and this instruction, this instruction will be two states longer.

The number of states may differ depending on the product. For details, refer to the relevant microcontroller hardware manual of the product in question.

**Notes**



**2.2.65 (1) SUB (B)****SUB (SUBtract binary)****Subtract Binary****Operation**

Rd – Rs → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

SUB.B Rs, Rd

- H: Set to 1 if there is a borrow at bit 3; otherwise cleared to 0.
- N: Set to 1 if the result is negative; otherwise cleared to 0.
- Z: Set to 1 if the result is zero; otherwise cleared to 0.
- V: Set to 1 if an overflow occurs; otherwise cleared to 0.
- C: Set to 1 if there is a borrow at bit 7; otherwise cleared to 0.

**Operand Size**

Byte

**Description**

This instruction subtracts the contents of an 8-bit register Rs (source operand) from the contents of an 8-bit register Rd (destination operand) and stores the result in the 8-bit register Rd.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

Rs: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Register direct | SUB.B    | Rs, Rd   | 1                  | 8        | rs       | rd       | 1             |

**SUB (SUBtract binary)****Subtract Binary**

---

**Notes**

The SUB.B instruction can operate only on general registers. Immediate data can be subtracted from general register contents by using the SUBX instruction. Before executing SUBX #xx:8, Rd, first set the Z flag to 1 and clear the C flag to 0. The following coding examples can also be used to subtract nonzero immediate data #IMM.

- (1) ORC    #H'05,CCR  
      SUBX  #(IMM-1),Rd
- (2) ADD    #(0-IMM),Rd  
      XORC  #H'01,CCR

**2.2.65 (2) SUB (W)****SUB (SUBtract binary)****Subtract Binary****Operation**

Rd – (EAs) → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

SUB.W &lt;EAs&gt;, Rd

- H: Set to 1 if there is a borrow at bit 11; otherwise cleared to 0.
- N: Set to 1 if the result is negative; otherwise cleared to 0.
- Z: Set to 1 if the result is zero; otherwise cleared to 0.
- V: Set to 1 if an overflow occurs; otherwise cleared to 0.
- C: Set to 1 if there is a borrow at bit 15; otherwise cleared to 0.

**Operand Size**

Word

**Description**

This instruction subtracts a source operand from the contents of a 16-bit register Rd (destination operand) and stores the result in the 16-bit register Rd.

**Available Registers**

Rd: R0 to R7, E0 to E7

Rs: R0 to R7, E0 to E7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands   | Instruction Format |          |          |          | No. of States |
|-----------------|----------|------------|--------------------|----------|----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | SUB.W    | #xx:16, Rd | 7   9              | 3   rd   | IMM      |          | 2             |
| Register direct | SUB.W    | Rs, Rd     | 1   9              | rs   rd  |          |          | 1             |

**Notes**

**2.2.65 (3) SUB (L)****SUB (SUBtract binary)****Subtract Binary****Operation**

ERd – (EAs) → ERd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

SUB .L &lt;EAs&gt;, ERd

**Operand Size**

Longword

H: Set to 1 if there is a borrow at bit 27; otherwise cleared to 0.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Set to 1 if there is a borrow at bit 31; otherwise cleared to 0.

**Description**

This instruction subtracts a source operand from the contents of a 32-bit register ERd (destination operand) and stores the result in the 32-bit register ERd.

**Available Registers**

ERd: ER0 to ER7

ERs: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands    | Instruction Format |   |          |     |          |          | No. of States |          |          |   |
|-----------------|----------|-------------|--------------------|---|----------|-----|----------|----------|---------------|----------|----------|---|
|                 |          |             | 1st byte           |   | 2nd byte |     | 3rd byte | 4th byte |               | 5th byte | 6th byte |   |
| Immediate       | SUB.L    | #xx:32, ERd | 7                  | A | 3        | 0   | erd      | IMM      |               |          | 3        |   |
| Register direct | SUB.L    | ERs, ERd    | 1                  | A | 1        | ers | 0        | erd      |               |          |          | 1 |

**Notes**

## 2.2.66 SUBS

**SUBS (SUBtract with Sign extension)**

**Subtract Binary Address Data**

### Operation

Rd – 1 → ERd

Rd – 2 → ERd

Rd – 4 → ERd

### Condition Code

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

### Assembly-Language Format

SUBS #1, ERd

SUBS #2, ERd

SUBS #4, ERd

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

### Operand Size

Longword

### Description

This instruction subtracts the immediate value 1, 2, or 4 from the contents of a 32-bit register ERd (destination operand). Unlike the SUB instruction, it does not affect the condition-code flags.

### Available Registers

ERd: ER0 to ER7

### Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |  |   |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|--|---|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |  |   |
| Register direct | SUBS     | #1, ERd  | 1                  | B        | 0        | 0        | erd           |  | 1 |
| Register direct | SUBS     | #2, ERd  | 1                  | B        | 8        | 0        | erd           |  | 1 |
| Register direct | SUBS     | #4, ERd  | 1                  | B        | 9        | 0        | erd           |  | 1 |

### Notes

## 2.2.67 SUBX

SUBX (SUBtract with eXtend carry)

Subtract with Borrow

**Operation**

Rd – (EAs) – C → Rd

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | ↑ | — | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

SUBX &lt;EAs&gt;, Rd

**Operand Size**

Byte

H: Set to 1 if there is a borrow at bit 3; otherwise cleared to 0.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Previous value remains unchanged when the result is zero; otherwise cleared to 0.

V: Set to 1 if an overflow occurs; otherwise cleared to 0.

C: Set to 1 if there is a borrow at bit 7; otherwise cleared to 0.

**Description**

This instruction subtracts the source operand and carry flag from the contents of an 8-bit register Rd (destination operand) and stores the result in the 8-bit register Rd.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands  | Instruction Format |          |          |          | No. of States |
|-----------------|----------|-----------|--------------------|----------|----------|----------|---------------|
|                 |          |           | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | SUBX     | #xx:8, Rd | B                  | rd       | IMM      |          | 1             |
| Register direct | SUBX     | Rs, Rd    | 1                  | E        | rs       | rd       | 1             |

**Notes**

**2.2.68 TAS****TAS (Test And Set)****Test and Set****Operation**

@ERd – 0 → set/clear CCR  
 1 → (<bit 7> of @ERd)

**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

TAS @ERd

- H: Previous value remains unchanged.  
 N: Set to 1 if the result is negative; otherwise cleared to 0.  
 Z: Set to 1 if the result is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction tests a memory operand by comparing it with zero, and sets the condition-code register according to the result. Then it sets the most significant bit (bit 7) of the operand to 1.

**Available Registers**

ERd: ER0, ER1, ER4, ER5

**Operand Format and Number of States Required for Execution**

| Addressing Mode   | Mnemonic | Operands | Instruction Format |   |          |   |          |   |          |     | No. of States |   |
|-------------------|----------|----------|--------------------|---|----------|---|----------|---|----------|-----|---------------|---|
|                   |          |          | 1st byte           |   | 2nd byte |   | 3rd byte |   | 4th byte |     |               |   |
| Register indirect | TAS      | @ERd     | 0                  | 1 | E        | 0 | 7        | B | 0        | erd | C             | 4 |

**Notes**

## 2.2.69 TRAPA

**TRAPA (TRAP Always)****Trap Unconditionally****Operation**

- When EXR is invalid  
PC → @-SP  
CCR → @-SP  
<Vector> → PC
- When EXR is valid  
PC → @-SP  
CCR → @-SP  
EXR → @-SP  
<Vector> → PC

**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| 1 | *  | — | — | — | — | — | — |

I: Always set to 1.

UI: See note.

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

**Assembly-Language Format**

TRAPA #x:2

Note: \* The UI bit is set to 1 when used as an interrupt mask bit, but retains its previous value when used as a user bit. For details, see the relevant microcontroller hardware manual.

**Operand Size**

—

**Description**

This instruction pushes the program counter (PC) and condition-code register (CCR) onto the stack, then sets the I bit to 1. If the extended control register (EXR) is valid, EXR is also saved onto the stack, but bits I2 to I0 are not modified. Next execution branches to a new address given by the contents of the vector address corresponding to the specified vector number. The PC value pushed onto the stack is the starting address of the next instruction after the TRAPA instruction.

| #x | Vector Address   |                      |
|----|------------------|----------------------|
|    | Normal Mode      | Advanced Mode        |
| 0  | H'0010 to H'0011 | H'000020 to H'000023 |
| 1  | H'0012 to H'0013 | H'000024 to H'000027 |
| 2  | H'0014 to H'0015 | H'000028 to H'00002B |
| 3  | H'0016 to H'0017 | H'00002C to H'00002F |



**TRAPA (TRAP Always)****Trap Unconditionally****Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands | Instruction Format |          |          |          | No. of States |    |
|-----------------|----------|----------|--------------------|----------|----------|----------|---------------|----|
|                 |          |          | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |    |
| Register direct | TRAPA    | #x:2     | 5                  | 7        | 00MM     | 0        |               | 7* |

Note: \* Eight states when EXR is valid.

**Notes**

The stack and vector structure differ between normal mode and advanced mode, and depending on whether EXR is valid or invalid.

**2.2.70 (1) XOR (B)****XOR (eXclusive OR logical)****Exclusive Logical OR****Operation**Rd  $\oplus$  (EAs)  $\rightarrow$  Rd**Condition Code**

| I | UI | H | U | N | Z | V | C |
|---|----|---|---|---|---|---|---|
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

XOR.B &lt;EAs&gt;, Rd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Byte

**Description**

This instruction exclusively ORs the source operand with the contents of an 8-bit register Rd (destination operand) and stores the result in the 8-bit register Rd.

**Available Registers**

Rd: R0L to R7L, R0H to R7H

Rs: R0L to R7L, R0H to R7H

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands  | Instruction Format |          |          |          | No. of States |
|-----------------|----------|-----------|--------------------|----------|----------|----------|---------------|
|                 |          |           | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | XOR.B    | #xx:8, Rd | D   rd             | IMM      |          |          | 1             |
| Register direct | XOR.B    | Rs, Rd    | 1   5              | rs   rd  |          |          | 1             |

**Notes**

**2.2.70 (2) XOR (W)****XOR (eXclusive OR logical)****Exclusive Logical OR****Operation**Rd  $\oplus$  (EAs)  $\rightarrow$  Rd**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

XOR.W &lt;EAs&gt;, Rd

- H: Previous value remains unchanged.  
 N: Set to 1 if the result is negative; otherwise cleared to 0.  
 Z: Set to 1 if the result is zero; otherwise cleared to 0.  
 V: Always cleared to 0.  
 C: Previous value remains unchanged.

**Operand Size**

Word

**Description**

This instruction exclusively ORs the source operand with the contents of a 16-bit register Rd (destination operand) and stores the result in the 16-bit register Rd.

**Available Registers**

Rd: R0 to R7, E0 to E7

Rs: R0 to R7, E0 to E7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands   | Instruction Format |          |          |          | No. of States |
|-----------------|----------|------------|--------------------|----------|----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | XOR.W    | #xx:16, Rd | 7   9              | 5   rd   | IMM      |          | 2             |
| Register direct | XOR.W    | Rs, Rd     | 6   5              | rs   rd  |          |          | 1             |

**Notes**

**2.2.70 (3) XOR (L)****XOR (eXclusive OR logical)****Exclusive Logical OR****Operation**ERd  $\oplus$  (EAs)  $\rightarrow$  ERd**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| — | —  | — | — | ↕ | ↕ | 0 | — |

**Assembly-Language Format**

XOR .L &lt;EAs&gt;, ERd

H: Previous value remains unchanged.

N: Set to 1 if the result is negative; otherwise cleared to 0.

Z: Set to 1 if the result is zero; otherwise cleared to 0.

V: Always cleared to 0.

C: Previous value remains unchanged.

**Operand Size**

Longword

**Description**

This instruction exclusively ORs the source operand with the contents of a 32-bit register ERd (destination operand) and stores the result in the 32-bit register ERd.

**Available Registers**

ERd: ER0 to ER7

ERs: ER0 to ER7

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands    | Instruction Format |   |          |   |          |          | No. of States |          |          |     |   |
|-----------------|----------|-------------|--------------------|---|----------|---|----------|----------|---------------|----------|----------|-----|---|
|                 |          |             | 1st byte           |   | 2nd byte |   | 3rd byte | 4th byte |               | 5th byte | 6th byte |     |   |
| Immediate       | XOR.L    | #xx:32, ERd | 7                  | A | 5        | 0 | IMM      |          |               |          | 3        |     |   |
| Register direct | XOR.L    | ERs, ERd    | 0                  | 1 | F        | 0 | 6        | 5        | 0             | ers      | 0        | erd | 2 |

**Notes**

## 2.2.71 (1) XORC

XORC (eXclusive OR Control register)

Exclusive Logical OR with CCR

**Operation**CCR  $\oplus$  #IMM  $\rightarrow$  CCR**Condition Code**

|   |    |   |   |   |   |   |   |
|---|----|---|---|---|---|---|---|
| I | UI | H | U | N | Z | V | C |
| ↑ | ↑  | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |

**Assembly-Language Format**

XORC #xx:8, CCR

- I: Stores the corresponding bit of the result.  
 UI: Stores the corresponding bit of the result.  
 H: Stores the corresponding bit of the result.  
 U: Stores the corresponding bit of the result.  
 N: Stores the corresponding bit of the result.  
 Z: Stores the corresponding bit of the result.  
 V: Stores the corresponding bit of the result.  
 C: Stores the corresponding bit of the result.

**Operand Size**

Byte

**Description**

This instruction exclusively ORs the contents of the condition-code register (CCR) with immediate data and stores the result in the condition-code register. No interrupt requests, including NMI, are accepted immediately after execution of this instruction.

**Operand Format and Number of States Required for Execution**

| Addressing Mode | Mnemonic | Operands   | Instruction Format |          |          |          | No. of States |
|-----------------|----------|------------|--------------------|----------|----------|----------|---------------|
|                 |          |            | 1st byte           | 2nd byte | 3rd byte | 4th byte |               |
| Immediate       | XORC     | #xx:8, CCR | 0                  | 5        | IMM      |          | 1             |

**Notes**

## 2.2.71 (2) XORC

## XORC (eXclusive OR Control register)

## Exclusive Logical OR with EXR

## Operation

EXR  $\oplus$  #IMM  $\rightarrow$  EXR

## Condition Code

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

## Assembly-Language Format

XORC #xx:8, EXR

H: Previous value remains unchanged.

N: Previous value remains unchanged.

Z: Previous value remains unchanged.

V: Previous value remains unchanged.

C: Previous value remains unchanged.

## Operand Size

Byte

## Description

This instruction exclusively ORs the contents of the extended control register (EXR) with immediate data and stores the result in the extended control register. No interrupt requests, including NMI, are accepted for three states after execution of this instruction.

## Operand Format and Number of States Required for Execution

| Addressing Mode | Mnemonic | Operands   | Instruction Format |   |          |   |          |   |          |  | No. of States |
|-----------------|----------|------------|--------------------|---|----------|---|----------|---|----------|--|---------------|
|                 |          |            | 1st byte           |   | 2nd byte |   | 3rd byte |   | 4th byte |  |               |
| Immediate       | XORC     | #xx:8, EXR | 0                  | 1 | 4        | 1 | 0        | 5 | IMM      |  | 2             |

## Notes

## 2.3 Instruction Set

Table 2.1 Instruction Set

## (1) Data Transfer Instructions

| Mnemonic               | Size | Addressing Mode and Instruction Length (Bytes) |    |     |      |           |     | Operation | Condition Code |     |   |   |   |   | No. of States <sup>*1</sup> |   |        |          |
|------------------------|------|--|----|-----|------|-----------|-----|-----------|----------------|-----|---|---|---|---|-----------------------------|---|--------|----------|
|                        |      | #xx  | Rn | @Rn | @ERn | @ERn@ERn+ | @aa |           | @(d,PC)        | @aa | I | H | N | Z | V                           | C | Normal | Advanced |
|                        |      |  |    |     |      |           |     |           |                |     |   |   |   |   |                             |   |        |          |
| MOV                    | B    | 2  |    |     |      |           |     |           |                |     |   |   |   |   |                             | 1 |        |          |
| MOV.B Rs, Rd           | B    | 2  |    |     |      |           |     |           |                |     |   |   |   |   |                             | 1 |        |          |
| MOV.B @Rs, Rd          | B    |  | 2  |     |      |           |     |           |                |     |   |   |   |   |                             | 1 |        |          |
| MOV.B @(d:16, ERs), Rd | B    |  |    | 4   |      |           |     |           |                |     |   |   |   |   |                             | 2 |        |          |
| MOV.B @(d:32, ERs), Rd | B    |  |    | 8   |      |           |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.B @ERs+, Rd        | B    |  |    |     | 2    |           |     |           |                |     |   |   |   |   |                             | 5 |        |          |
| MOV.B @ERs+, Rd        | B    |  |    |     | 2    |           |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.B @aa:8, Rd        | B    |  |    |     |      | 2         |     |           |                |     |   |   |   |   |                             | 2 |        |          |
| MOV.B @aa:16, Rd       | B    |  |    |     |      | 4         |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.B @aa:32, Rd       | B    |  |    |     |      | 6         |     |           |                |     |   |   |   |   |                             | 4 |        |          |
| MOV.B Rs, @ERd         | B    |  | 2  |     |      |           |     |           |                |     |   |   |   |   |                             | 2 |        |          |
| MOV.B Rs, @(d:16, ERd) | B    |  |    | 4   |      |           |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.B Rs, @(d:32, ERd) | B    |  |    | 8   |      |           |     |           |                |     |   |   |   |   |                             | 5 |        |          |
| MOV.B Rs, @-ERd        | B    |  |    |     | 2    |           |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.B Rs, @aa:8        | B    |  |    |     |      | 2         |     |           |                |     |   |   |   |   |                             | 2 |        |          |
| MOV.B Rs, @aa:16       | B    |  |    |     |      | 4         |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.B Rs, @aa:32       | B    |  |    |     |      | 6         |     |           |                |     |   |   |   |   |                             | 4 |        |          |
| MOV.W #xx:16, Rd       | W    | 4  |    |     |      |           |     |           |                |     |   |   |   |   |                             | 2 |        |          |
| MOV.W Rs, Rd           | W    |  | 2  |     |      |           |     |           |                |     |   |   |   |   |                             | 2 |        |          |
| MOV.W @ERs, Rd         | W    |  |    | 2   |      |           |     |           |                |     |   |   |   |   |                             | 1 |        |          |
| MOV.W @(d:16, ERs), Rd | W    |  |    | 4   |      |           |     |           |                |     |   |   |   |   |                             | 2 |        |          |
| MOV.W @(d:32, ERs), Rd | W    |  |    | 8   |      |           |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.W @ERs+, Rd        | W    |  |    |     | 2    |           |     |           |                |     |   |   |   |   |                             | 5 |        |          |
| MOV.W @ERs+, Rd        | W    |  |    |     | 2    |           |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.W @aa:16, Rd       | W    |  |    |     |      | 4         |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.W @aa:32, Rd       | W    |  |    |     |      | 6         |     |           |                |     |   |   |   |   |                             | 4 |        |          |
| MOV.W Rs, @ERd         | W    |  | 2  |     |      |           |     |           |                |     |   |   |   |   |                             | 2 |        |          |
| MOV.W Rs, @(d:16, ERd) | W    |  |    | 4   |      |           |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.W Rs, @(d:32, ERd) | W    |  |    | 8   |      |           |     |           |                |     |   |   |   |   |                             | 5 |        |          |
| MOV.W Rs, @-ERd        | W    |  |    |     | 2    |           |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.W Rs, @aa:16       | W    |  |    |     |      | 4         |     |           |                |     |   |   |   |   |                             | 3 |        |          |
| MOV.W Rs, @aa:32       | W    |  |    |     |      | 6         |     |           |                |     |   |   |   |   |                             | 4 |        |          |

| Mnemonic | Size | Addressing Mode and Instruction Length (Bytes) |    |      |          |             |         | Operation | Condition Code |         |   |   |   |   | No. of States*1 |   |   |          |
|----------|------|--|----|------|----------|-------------|---------|-----------|----------------|---------|---|---|---|---|-----------------|---|---|----------|
|          |      | #xx  | Rn | @ERn | @(d,ERn) | @-ERn/@ERn+ | @(d,PC) |           | @aa            | @(d,PC) | I | H | N | Z |                 | V | C | Normal   |
| MOV      | L    | 6  |    |      |          |             |         |           |                |         |   |   |   |   |                 |   |   | 3        |
|          | L    |  | 2  |      |          |             |         |           |                |         |   |   |   |   |                 |   |   | 1        |
|          | L    |  | 4  |      |          |             |         |           |                |         |   |   |   |   |                 |   |   | 4        |
|          | L    |  |    | 6    |          |             |         |           |                |         |   |   |   |   |                 |   |   | 5        |
|          | L    |  |    | 10   |          |             |         |           |                |         |   |   |   |   |                 |   |   | 7        |
|          | L    |  |    | 4    |          |             |         |           |                |         |   |   |   |   |                 |   |   | 5        |
|          | L    |  |    |      | 6        |             |         |           |                |         |   |   |   |   |                 |   |   | 5        |
|          | L    |  |    |      | 8        |             |         |           |                |         |   |   |   |   |                 |   |   | 6        |
|          | L    |  | 4  |      |          |             |         |           |                |         |   |   |   |   |                 |   |   | 4        |
|          | L    |  |    | 6    |          |             |         |           |                |         |   |   |   |   |                 |   |   | 5        |
|          | L    |  |    | 10   |          |             |         |           |                |         |   |   |   |   |                 |   |   | 7        |
|          | L    |  |    | 4    |          |             |         |           |                |         |   |   |   |   |                 |   |   | 5        |
|          | L    |  |    |      | 6        |             |         |           |                |         |   |   |   |   |                 |   |   | 5        |
|          | L    |  |    |      | 8        |             |         |           |                |         |   |   |   |   |                 |   |   | 6        |
| POP      | W    |  |    |      |          |             |         |           |                |         |   |   |   |   |                 |   |   | 3        |
|          | L    |  |    |      |          |             |         |           |                | 2       |   |   |   |   |                 |   |   | 3        |
| PUSH     | W    |  |    |      |          |             |         |           |                | 4       |   |   |   |   |                 |   |   | 5        |
|          | L    |  |    |      |          |             |         |           |                | 2       |   |   |   |   |                 |   |   | 3        |
|          | L    |  |    |      |          |             |         |           |                | 4       |   |   |   |   |                 |   |   | 5        |
| LDM      | L    |  |    |      |          |             |         |           |                | 4       |   |   |   |   |                 |   |   | 7/9/11*3 |
| STM      | L    |  |    |      |          |             |         |           |                | 4       |   |   |   |   |                 |   |   | 7/9/11*3 |
| MOVFP    | B    |  |    |      |          |             |         |           |                | 4       |   |   |   |   |                 |   |   | (1)      |
| MOVTP    | B    |  |    |      |          |             |         |           |                | 4       |   |   |   |   |                 |   |   | (1)      |





| Mnemonic | Size | Addressing Mode and Instruction Length (Bytes) |    |      |        |             |       | Operation | Condition Code |     |     |     |     |   |                    | No. of States*1 |   |                 |          |
|----------|------|--|----|------|--------|-------------|-------|-----------|----------------|-----|-----|-----|-----|---|--------------------|-----------------|---|-----------------|----------|
|          |      | #xx  | Rn | @ERn | @d,ERn | @-ERn/@ERn+ | @d,PC |           | @aa            | @aa | I   | H   | N   | Z | V                  |                 | C | No. of States*1 |          |
|          |      |  |    |      |        |             |       |           |                |     |     |     |     |   |                    |                 |   | Normal          | Advanced |
| DAS      | B    | 2  |    |      |        |             |       |           |                |     | *   | ↓   | ↓   | * | —                  | 1               |   |                 |          |
| MULXU    | B    | 2  |    |      |        |             |       |           |                |     |     |     |     |   | 3 (12*7)<br>*4 *10 |                 |   |                 |          |
| MULXU    | W    | 2  |    |      |        |             |       |           |                |     |     |     |     |   | 4 (20*7)<br>*4 *10 |                 |   |                 |          |
| MULXS    | B    | 4  |    |      |        |             |       |           |                |     |     | ↓   | ↓   |   | 4 (13*7)<br>*5 *10 |                 |   |                 |          |
| MULXS    | W    | 4  |    |      |        |             |       |           |                |     |     | ↓   | ↓   |   | 5 (21*7)<br>*5 *10 |                 |   |                 |          |
| DIVXU    | B    | 2  |    |      |        |             |       |           |                |     |     | (5) | (6) |   | 12                 |                 |   |                 |          |
| DIVXU    | W    | 2  |    |      |        |             |       |           |                |     |     | (5) | (6) |   | 20                 |                 |   |                 |          |
| DIVXS    | B    | 4  |    |      |        |             |       |           |                |     |     | (7) | (6) |   | 13                 |                 |   |                 |          |
| DIVXS    | W    | 4  |    |      |        |             |       |           |                |     |     | (7) | (6) |   | 21                 |                 |   |                 |          |
| CMP      | B    | 2  |    |      |        |             |       |           |                |     | ↓   | ↓   | ↓   | ↓ | 1                  |                 |   |                 |          |
| CMP      | B    | 2  |    |      |        |             |       |           |                |     | ↓   | ↓   | ↓   | ↓ | 1                  |                 |   |                 |          |
| CMP      | W    | 4  |    |      |        |             |       |           |                |     | (2) | ↓   | ↓   | ↓ | 2                  |                 |   |                 |          |
| CMP      | W    | 2  |    |      |        |             |       |           |                |     | (2) | ↓   | ↓   | ↓ | 1                  |                 |   |                 |          |
| CMP      | L    | 6  |    |      |        |             |       |           |                |     | (3) | ↓   | ↓   | ↓ | 3                  |                 |   |                 |          |
| CMP      | L    | 2  |    |      |        |             |       |           |                |     | (3) | ↓   | ↓   | ↓ | 1                  |                 |   |                 |          |
| NEG      | B    | 2  |    |      |        |             |       |           |                |     |     | ↓   | ↓   | ↓ | 1                  |                 |   |                 |          |
| NEG      | W    | 2  |    |      |        |             |       |           |                |     |     | ↓   | ↓   | ↓ | 1                  |                 |   |                 |          |
| EXTU     | W    | 2  |    |      |        |             |       |           |                |     |     | 0   | ↓   | 0 | 1                  |                 |   |                 |          |
| EXTU     | L    | 2  |    |      |        |             |       |           |                |     |     | 0   | ↓   | 0 | 1                  |                 |   |                 |          |
| EXTS     | W    | 2  |    |      |        |             |       |           |                |     |     | ↓   | ↓   | 0 | 1                  |                 |   |                 |          |
| EXTS     | L    | 2  |    |      |        |             |       |           |                |     |     | ↓   | ↓   | 0 | 1                  |                 |   |                 |          |
| TAS      | B    |  | 4  |      |        |             |       |           |                |     |     | ↓   | ↓   | 0 | 4                  |                 |   |                 |          |

| Mnemonic             | Size | Addressing Mode and Instruction Length (Bytes) |    |      |          |             |     |         |     | Operation | Condition Code |   |   |   |   | No. of States <sup>*1</sup> |        |          |  |                     |
|----------------------|------|--|----|------|----------|-------------|-----|---------|-----|-----------|----------------|---|---|---|---|-----------------------------|--------|----------|--|---------------------|
|                      |      | #xx  | Rn | @ERn | @(d,ERn) | @-ERn/@ERn+ | @aa | @(d,PC) | @aa |           | I              | H | N | Z | V | C                           | Normal | Advanced |  |                     |
| MAC <sup>*9</sup>    | —    |  |    |      |          | 4           |     |         |     | 1         |                |   |   |   |   |                             |        | 4        |  |                     |
| CLRMAC <sup>*9</sup> | —    |  |    |      |          |             |     |         |     |           |                |   |   |   |   |                             |        |          |  | 2 <sup>*6</sup> *10 |
| LDMAC <sup>*9</sup>  | L    | 2  |    |      |          |             |     |         |     | 2         |                |   |   |   |   |                             |        |          |  | 2 <sup>*6</sup> *10 |
| STMAC <sup>*9</sup>  | L    | 2  |    |      |          |             |     |         |     |           |                |   |   |   |   |                             |        |          |  | 2 <sup>*6</sup> *10 |
| STMACL               | L    | 2  |    |      |          |             |     |         |     |           |                |   |   |   |   |                             |        |          |  | 1 <sup>*6</sup> *10 |
| STMACLERD            | L    | 2  |    |      |          |             |     |         |     |           |                |   |   |   |   |                             |        |          |  | 1 <sup>*6</sup> *10 |



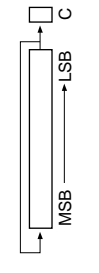
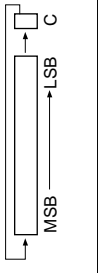
## (3) Logic Operation Instructions

| Mnemonic | Size              | Addressing Mode and Instruction Length (Bytes) |    |       |            |               |      |           | Operation | Condition Code |   |   |   |   |   |   | No. of States <sup>*1</sup> |          |  |
|----------|-------------------|--|----|-------|------------|---------------|------|-----------|-----------|----------------|---|---|---|---|---|---|-----------------------------|----------|--|
|          |                   | #xx  | Rn | @ ERn | @ (d, ERn) | @ -ERn/@ ERn+ | @ aa | @ (d, PC) |           | @ aa           | I | H | N | Z | V | C | Normal                      | Advanced |  |
|          |                   |  |    |       |            |               |      |           |           |                |   |   |   |   |   |   |                             |          |  |
| AND      | AND.B #xx:8, Rd   | B  | 2  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 1        |  |
|          | AND.B Rs, Rd      | B  | 2  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 1        |  |
|          | AND.W #xx:16, Rd  | W  | 4  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 2        |  |
|          | AND.W Rs, Rd      | W  | 4  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 2        |  |
|          | AND.L #xx:32, ERd | L  | 6  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 3        |  |
|          | AND.L ERs, ERd    | L  | 6  | 4     |            |               |      |           |           |                |   |   |   |   |   |   |                             | 3        |  |
| OR       | OR.B #xx:8, Rd    | B  | 2  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 1        |  |
|          | OR.B Rs, Rd       | B  | 2  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 1        |  |
|          | OR.W #xx:16, Rd   | W  | 4  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 2        |  |
|          | OR.W Rs, Rd       | W  | 4  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 2        |  |
|          | OR.L #xx:32, ERd  | L  | 6  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 3        |  |
|          | OR.L ERs, ERd     | L  | 6  | 4     |            |               |      |           |           |                |   |   |   |   |   |   |                             | 3        |  |
| XOR      | XOR.B #xx:8, Rd   | B  | 2  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 1        |  |
|          | XOR.B Rs, Rd      | B  | 2  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 1        |  |
|          | XOR.W #xx:16, Rd  | W  | 4  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 2        |  |
|          | XOR.W Rs, Rd      | W  | 4  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 2        |  |
|          | XOR.L #xx:32, ERd | L  | 6  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 3        |  |
|          | XOR.L ERs, ERd    | L  | 6  | 4     |            |               |      |           |           |                |   |   |   |   |   |   |                             | 3        |  |
| NOT      | NOT.B Rd          | B  | 2  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 1        |  |
|          | NOT.W Rd          | W  | 2  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 1        |  |
|          | NOT.L ERd         | L  | 2  |       |            |               |      |           |           |                |   |   |   |   |   |   |                             | 1        |  |

(4) Shift Instructions

| Mnemonic | Size          | Addressing Mode and Instruction Length (Bytes) |    |      |          |             |     | Operation | Condition Code |     |   |   |   |   | No. of States*1 |   |        |
|----------|---------------|--|----|------|----------|-------------|-----|-----------|----------------|-----|---|---|---|---|-----------------|---|--------|
|          |               | #xx  | Rn | @ERn | @(d,ERn) | @-ERn/@ERn+ | @aa |           | @(d,PC)        | @aa | I | H | N | Z | V               | C | Normal |
| SHAL     | SHALB Rd      | B  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHALB #2,Rd   | B  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHALW Rd      | W  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHALW #2,Rd   | W  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHALL ERd     | L  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHALL #2,ERd  | L  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
| SHAR     | SHARB Rd      | B  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHARB #2,Rd   | B  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHARW Rd      | W  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHARW #2,Rd   | W  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHARL ERd     | L  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHARL #2,ERd  | L  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
| SHLL     | SHLLB Rd      | B  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHLLB #2,Rd   | B  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHLLW Rd      | W  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHLLW #2,Rd   | W  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHLLL ERd     | L  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHLLL #2,ERd  | L  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
| SHLR     | SHLRB Rd      | B  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHLRB #2,Rd   | B  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHLRW Rd      | W  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHLRW #2,Rd   | W  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHLRL ERd     | L  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | SHLRL #2,ERd  | L  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
| ROTXL    | ROTXLB Rd     | B  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | ROTXLB #2,Rd  | B  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | ROTXLW Rd     | W  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | ROTXLW #2,Rd  | W  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | ROTXLL ERd    | L  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | ROTXLL #2,ERd | L  | 2  |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |

| Mnemonic | Size | Addressing Mode and Instruction Length (Bytes) |    |      |          |             |     | Operation | Condition Code |     |   |   |   |   | No. of States*1 |   |        |
|----------|------|--|----|------|----------|-------------|-----|-----------|----------------|-----|---|---|---|---|-----------------|---|--------|
|          |      | #xx  | Rn | @ERn | @(d,ERn) | @-ERn/@ERn+ | @aa |           | @(d,PC)        | @aa | I | H | N | Z | V               | C | Normal |
| ROTXR    | B    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | B    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | W    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | W    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | L    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | L    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
| ROTL     | B    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | B    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | W    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | W    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | L    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | L    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
| ROTR     | B    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | B    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | W    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | W    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | L    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |
|          | L    | 2  |    |      |          |             |     |           |                |     |   |   |   |   |                 | 1 |        |



## (5) Bit Manipulation Instructions

| Mnemonic          | Size              | Addressing Mode and Instruction Length (Bytes) |    |      |        |             |     | Operation | Condition Code |   |   |   |   | No. of States*1 |   |   |   |                 |          |
|-------------------|-------------------|--|----|------|--------|-------------|-----|-----------|----------------|---|---|---|---|-----------------|---|---|---|-----------------|----------|
|                   |                   | #xx  | Rn | @ERn | @d,ERn | @-ERn/@ERn+ | @aa |           | @d,PC          | I | I | H | N |                 | Z | V | C | No. of States*1 |          |
|                   |                   |  |    |      |        |             |     |           |                |   |   |   |   |                 |   |   |   | Normal          | Advanced |
| BSET              | BSET #xx:3,Rd     | B  | 2  |      |        |             |     |           |                |   |   |   |   |                 |   |   |   | 1               |          |
|                   | BSET #xx:3,@ERd   | B  |    | 4    |        |             |     |           |                |   |   |   |   |                 |   |   |   | 4               |          |
|                   | BSET #xx:3,@aa:8  | B  |    |      | 4      |             |     |           |                |   |   |   |   |                 |   |   |   | 4               |          |
|                   | BSET #xx:3,@aa:16 | B  |    |      |        | 6           |     |           |                |   |   |   |   |                 |   |   |   | 5               |          |
|                   | BSET #xx:3,@aa:32 | B  |    |      |        | 8           |     |           |                |   |   |   |   |                 |   |   |   | 6               |          |
|                   | BSET Rn,Rd        | B  | 2  |      |        |             |     |           |                |   |   |   |   |                 |   |   |   | 1               |          |
|                   | BSET Rn,@ERd      | B  |    | 4    |        |             |     |           |                |   |   |   |   |                 |   |   |   | 4               |          |
|                   | BSET Rn,@aa:8     | B  |    |      | 4      |             |     |           |                |   |   |   |   |                 |   |   |   | 4               |          |
|                   | BSET Rn,@aa:16    | B  |    |      |        | 6           |     |           |                |   |   |   |   |                 |   |   |   | 5               |          |
|                   | BSET Rn,@aa:32    | B  |    |      |        | 8           |     |           |                |   |   |   |   |                 |   |   |   | 6               |          |
|                   | BCLR              | BCLR #xx:3,Rd                                  | B  | 2    |        |             |     |           |                |   |   |   |   |                 |   |   |   |                 | 1        |
|                   |                   | BCLR #xx:3,@ERd                                | B  |      | 4      |             |     |           |                |   |   |   |   |                 |   |   |   |                 | 4        |
| BCLR #xx:3,@aa:8  |                   | B  |    |      | 4      |             |     |           |                |   |   |   |   |                 |   |   |   | 4               |          |
| BCLR #xx:3,@aa:16 |                   | B  |    |      |        | 6           |     |           |                |   |   |   |   |                 |   |   |   | 5               |          |
| BCLR #xx:3,@aa:32 |                   | B  |    |      |        | 8           |     |           |                |   |   |   |   |                 |   |   |   | 6               |          |
| BCLR Rn,Rd        |                   | B  | 2  |      |        |             |     |           |                |   |   |   |   |                 |   |   |   | 1               |          |
| BCLR Rn,@ERd      |                   | B  |    | 4    |        |             |     |           |                |   |   |   |   |                 |   |   |   | 4               |          |
| BCLR Rn,@aa:8     |                   | B  |    |      | 4      |             |     |           |                |   |   |   |   |                 |   |   |   | 4               |          |
| BCLR Rn,@aa:16    |                   | B  |    |      |        | 6           |     |           |                |   |   |   |   |                 |   |   |   | 5               |          |
| BCLR Rn,@aa:32    |                   | B  |    |      |        | 8           |     |           |                |   |   |   |   |                 |   |   |   | 6               |          |
| BNOT              |                   | BNOT #xx:3,Rd                                  | B  | 2    |        |             |     |           |                |   |   |   |   |                 |   |   |   |                 | 1        |
|                   |                   | BNOT #xx:3,@ERd                                | B  |      | 4      |             |     |           |                |   |   |   |   |                 |   |   |   |                 | 4        |
|                   | BNOT #xx:3,@aa:8  | B  |    |      | 4      |             |     |           |                |   |   |   |   |                 |   |   |   | 4               |          |
|                   | BNOT #xx:3,@aa:16 | B  |    |      |        | 6           |     |           |                |   |   |   |   |                 |   |   |   | 5               |          |
|                   | BNOT #xx:3,@aa:32 | B  |    |      |        | 8           |     |           |                |   |   |   |   |                 |   |   |   | 6               |          |
|                   | BNOT Rn,Rd        | B  | 2  |      |        |             |     |           |                |   |   |   |   |                 |   |   |   | 1               |          |
|                   | BNOT Rn,@ERd      | B  |    | 4    |        |             |     |           |                |   |   |   |   |                 |   |   |   | 4               |          |
|                   | BNOT Rn,@aa:8     | B  |    |      | 4      |             |     |           |                |   |   |   |   |                 |   |   |   | 4               |          |
|                   | BNOT Rn,@aa:16    | B  |    |      |        | 6           |     |           |                |   |   |   |   |                 |   |   |   | 5               |          |
|                   | BNOT Rn,@aa:32    | B  |    |      |        | 8           |     |           |                |   |   |   |   |                 |   |   |   | 6               |          |

| Mnemonic | Size | Addressing Mode and Instruction Length (Bytes) |    |       |            |             |     |           | Operation | Condition Code |   |                |   |   | No. of States*1 |        |          |
|----------|------|--|----|-------|------------|-------------|-----|-----------|-----------|----------------|---|----------------|---|---|-----------------|--------|----------|
|          |      | #xx  | Rn | @ ERn | @ (d, ERn) | @ -ERn/ERn+ | @aa | @ (d, PC) |           | @aa            | I | Condition Code |   |   |                 | Normal | Advanced |
|          |      |  |    |       |            |             |     |           |           |                |   | I              | H | N | Z               |        |          |
| BTST     | B    | 2  |    |       |            |             |     |           |           |                |   |                |   |   |                 |        | 1        |
|          | B    |  | 4  |       |            |             |     |           |           |                |   |                |   |   |                 |        | 3        |
|          | B    |  |    | 4     |            |             |     |           |           |                |   |                |   |   |                 |        | 3        |
|          | B    |  |    |       | 4          |             |     |           |           |                |   |                |   |   |                 |        | 4        |
|          | B    |  |    |       |            | 8           |     |           |           |                |   |                |   |   |                 |        | 5        |
|          | B    | 2  |    |       |            |             |     |           |           |                |   |                |   |   |                 |        | 1        |
|          | B    |  | 4  |       |            |             |     |           |           |                |   |                |   |   |                 |        | 3        |
|          | B    |  |    |       |            | 4           |     |           |           |                |   |                |   |   |                 |        | 3        |
|          | B    |  |    |       |            |             | 6   |           |           |                |   |                |   |   |                 |        | 4        |
|          | B    |  |    |       |            |             |     | 8         |           |                |   |                |   |   |                 |        | 5        |
|          | B    |  |    |       |            |             |     |           | 8         |                |   |                |   |   |                 |        | 4        |
|          | BLD  | B  | 2  |       |            |             |     |           |           |                |   |                |   |   |                 |        |          |
| B        |      |  | 4  |       |            |             |     |           |           |                |   |                |   |   |                 |        | 3        |
| B        |      |  |    | 4     |            |             |     |           |           |                |   |                |   |   |                 |        | 3        |
| B        |      |  |    |       | 4          |             |     |           |           |                |   |                |   |   |                 |        | 4        |
| B        |      |  |    |       |            | 6           |     |           |           |                |   |                |   |   |                 |        | 4        |
| B        |      |  |    |       |            |             | 8   |           |           |                |   |                |   |   |                 |        | 5        |
| B        |      | 2  |    |       |            |             |     |           |           |                |   |                |   |   |                 |        | 1        |
| B        |      |  | 4  |       |            |             |     |           |           |                |   |                |   |   |                 |        | 3        |
| B        |      |  |    |       |            | 4           |     |           |           |                |   |                |   |   |                 |        | 4        |
| B        |      |  |    |       |            |             | 6   |           |           |                |   |                |   |   |                 |        | 4        |
| B        |      |  |    |       |            |             |     | 8         |           |                |   |                |   |   |                 |        | 5        |
| B        |      |  |    |       |            |             |     |           | 8         |                |   |                |   |   |                 |        | 1        |
| BILD     | B    | 2  |    |       |            |             |     |           |           |                |   |                |   |   |                 |        | 1        |
|          | B    |  | 4  |       |            |             |     |           |           |                |   |                |   |   |                 |        | 3        |
|          | B    |  |    | 4     |            |             |     |           |           |                |   |                |   |   |                 |        | 3        |
|          | B    |  |    |       | 4          |             |     |           |           |                |   |                |   |   |                 |        | 4        |
|          | B    |  |    |       |            | 6           |     |           |           |                |   |                |   |   |                 |        | 4        |
|          | B    |  |    |       |            |             | 8   |           |           |                |   |                |   |   |                 |        | 5        |
|          | B    | 2  |    |       |            |             |     |           |           |                |   |                |   |   |                 |        | 1        |
|          | B    |  | 4  |       |            |             |     |           |           |                |   |                |   |   |                 |        | 4        |
|          | B    |  |    |       |            | 4           |     |           |           |                |   |                |   |   |                 |        | 4        |
|          | B    |  |    |       |            |             | 6   |           |           |                |   |                |   |   |                 |        | 5        |
|          | B    |  |    |       |            |             |     | 8         |           |                |   |                |   |   |                 |        | 6        |
|          | B    |  |    |       |            |             |     |           | 8         |                |   |                |   |   |                 |        | 1        |
| BIST     | B    | 2  |    |       |            |             |     |           |           |                |   |                |   |   |                 |        | 1        |
|          | B    |  | 4  |       |            |             |     |           |           |                |   |                |   |   |                 |        | 4        |
|          | B    |  |    | 4     |            |             |     |           |           |                |   |                |   |   |                 |        | 4        |
|          | B    |  |    |       | 4          |             |     |           |           |                |   |                |   |   |                 |        | 5        |
|          | B    |  |    |       |            | 6           |     |           |           |                |   |                |   |   |                 |        | 5        |
|          | B    |  |    |       |            |             | 8   |           |           |                |   |                |   |   |                 |        | 6        |



| Mnemonic | Size                | Addressing Mode and Instruction Length (Bytes) |    |      |           |           |     | Operation | Condition Code |     |   |   |   |   | No. of States <sup>*1</sup> |   |        |          |
|----------|---------------------|--|----|------|-----------|-----------|-----|-----------|----------------|-----|---|---|---|---|-----------------------------|---|--------|----------|
|          |                     | #xx  | Rn | @ERn | @(d, ERn) | -ERn/ERn+ | @aa |           | @(d, PC)       | @aa | I | H | N | Z | V                           | C | Normal | Advanced |
|          |                     |  |    |      |           |           |     |           |                |     |   |   |   |   |                             |   |        |          |
| BAND     | BAND #xx:3, Rd      | B  | 2  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 1      |          |
|          | BAND #xx:3, @ERd    | B  | 4  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
|          | BAND #xx:3, @aa:8   | B  |    | 4    |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
|          | BAND #xx:3, @aa:16  | B  |    | 6    |           |           |     |           |                |     |   |   |   |   |                             |   | 4      |          |
|          | BAND #xx:3, @aa:32  | B  |    | 8    |           |           |     |           |                |     |   |   |   |   |                             |   | 5      |          |
|          | BAND #xx:3, Rd      | B  | 2  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 1      |          |
|          | BAND #xx:3, @ERd    | B  | 4  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
|          | BAND #xx:3, @aa:8   | B  |    | 4    |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
| BOR      | BAND #xx:3, @aa:16  | B  |    | 6    |           |           |     |           |                |     |   |   |   |   |                             |   | 4      |          |
|          | BAND #xx:3, @aa:32  | B  |    | 8    |           |           |     |           |                |     |   |   |   |   |                             |   | 5      |          |
|          | BOR #xx:3, Rd       | B  | 2  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 1      |          |
|          | BOR #xx:3, @ERd     | B  | 4  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
|          | BOR #xx:3, @aa:8    | B  |    | 4    |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
|          | BOR #xx:3, @aa:16   | B  |    | 6    |           |           |     |           |                |     |   |   |   |   |                             |   | 4      |          |
|          | BOR #xx:3, @aa:32   | B  |    | 8    |           |           |     |           |                |     |   |   |   |   |                             |   | 5      |          |
|          | BIOR #xx:3, @ERd    | B  | 2  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 1      |          |
| BXOR     | BIOR #xx:3, @ERd    | B  | 4  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
|          | BIOR #xx:3, @aa:8   | B  |    | 4    |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
|          | BIOR #xx:3, @aa:16  | B  |    | 6    |           |           |     |           |                |     |   |   |   |   |                             |   | 4      |          |
|          | BIOR #xx:3, @aa:32  | B  |    | 8    |           |           |     |           |                |     |   |   |   |   |                             |   | 5      |          |
|          | BXOR #xx:3, Rd      | B  | 2  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 1      |          |
|          | BXOR #xx:3, @ERd    | B  | 4  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
|          | BXOR #xx:3, @aa:8   | B  |    | 4    |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
|          | BXOR #xx:3, @aa:16  | B  |    | 6    |           |           |     |           |                |     |   |   |   |   |                             |   | 4      |          |
| BIXOR    | BXOR #xx:3, @aa:32  | B  |    | 8    |           |           |     |           |                |     |   |   |   |   |                             |   | 5      |          |
|          | BIXOR #xx:3, Rd     | B  | 2  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 1      |          |
|          | BIXOR #xx:3, @ERd   | B  | 4  |      |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
|          | BIXOR #xx:3, @aa:8  | B  |    | 4    |           |           |     |           |                |     |   |   |   |   |                             |   | 3      |          |
|          | BIXOR #xx:3, @aa:16 | B  |    | 6    |           |           |     |           |                |     |   |   |   |   |                             |   | 4      |          |
|          | BIXOR #xx:3, @aa:32 | B  |    | 8    |           |           |     |           |                |     |   |   |   |   |                             |   | 5      |          |







| Mnemonic | Size | Addressing Mode and Instruction Length (Bytes) |    |      |         |           |     |       | Operation | Condition Code |   |   |   |   |   |   | No. of States*1 |          |
|----------|------|--|----|------|---------|-----------|-----|-------|-----------|----------------|---|---|---|---|---|---|-----------------|----------|
|          |      | #xx  | Rn | @ERn | (d,ERn) | -ERn/ERn+ | @aa | @d,PC |           | @aa            | I | H | N | Z | V | C | Normal          | Advanced |
|          |      |  |    |      |         |           |     |       |           |                |   |   |   |   |   |   |                 |          |
| STC      | B    | 2  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 1               |          |
|          | B    | 2  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 1               |          |
|          | W    | 4  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 3               |          |
|          | W    | 4  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 3               |          |
|          | W    | 6  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 4               |          |
|          | W    | 6  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 4               |          |
|          | W    | 10   |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 6               |          |
|          | W    | 10   |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 6               |          |
|          | W    | 4  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 4               |          |
|          | W    | 4  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 4               |          |
|          | W    | 6  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 4               |          |
|          | W    | 6  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 4               |          |
|          | W    | 8  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 5               |          |
|          | W    | 8  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 5               |          |
| ANDC     | B    | 2  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 1               |          |
|          | B    | 4  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 2               |          |
| ORC      | B    | 2  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 1               |          |
|          | B    | 4  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 2               |          |
| XORC     | B    | 2  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 1               |          |
|          | B    | 4  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 2               |          |
| NOP      | —    |  |    |      |         |           |     |       |           |                |   |   |   |   |   |   | 1               |          |

## (8) Block Transfer Instructions

| Mnemonic | Size | Addressing Mode and Instruction Length (Bytes) |    |           |             |           |     | Operation | Condition Code  |   |   |   |   |   | No. of States*1 |        |                   |
|----------|------|--|----|-----------|-------------|-----------|-----|-----------|---|---|---|---|---|---|-----------------|--------|-------------------|
|          |      | #xx  | Rn | @(d, ERn) | @-ERn/@ERn+ | @(d, P/C) | @aa |           | @aa   | I | H | N | Z | V | C               | Normal | Advanced          |
| EEPMOVB  | —    |  |    |           |             |           |     | 4         | if R4L ≠ 0<br>Repeat @ER5+→@ER6+<br>ER5+1→ER5<br>ER6+1→ER6<br>R4L-1→R4L<br>Until R4L=0<br>else next;<br>if R4 ≠ 0<br>Repeat @ER5+→@ER6+<br>ER5+1→ER5<br>ER6+1→ER6<br>R4-1→4<br>Until R4=0<br>else next; | — | — | — | — | — | —               | —      | 4+2n <sup>2</sup> |
| EEPMOVW  | —    |  |    |           |             |           |     | 4         | if R4 ≠ 0<br>Repeat @ER5+→@ER6+<br>ER5+1→ER5<br>ER6+1→ER6<br>R4-1→4<br>Until R4=0<br>else next;   | — | — | — | — | — | —               | —      | 4+2n <sup>2</sup> |

Notes: 1. The number of states is the number of states required for execution when the instruction and its operands are located in on-chip memory.

2. n is the initial setting of R4L or R4.

3. Seven states for saving or restoring two registers, nine states for three registers, or eleven states for four registers.

4. One additional state is required for execution immediately after a MULXU, MULXS, or STMAC instruction. Also, a maximum of three additional states are required for execution of a MULXU instruction within three states after execution of a MAC instruction. For example, if there is a one-state instruction (such as NOP) between a MAC instruction and a MULXU instruction, the MULXU instruction will be two states longer.

5. A maximum of two additional states are required for execution of a MULXS instruction within two states after execution of a MAC instruction.

For example, if there is a one-state instruction (such as NOP) between a MAC instruction and a MULXS instruction, the MULXS instruction will be one state longer.

6. A maximum of three additional states are required for execution of one of these instructions within three states after execution of a MAC instruction.

For example, if there is a one-state instruction (such as NOP) between a MAC instruction and one of these instructions, that instruction will be two states longer.

7. Values in parentheses ( ) are for the H8S/2000 CPU. Values in square brackets [ ] apply to interrupt control modes 2 and 3.

8. Only register ER0, ER1, ER4, or ER5 should be used when using the TAS instruction.

9. These instructions are supported only by the H8S/2600 CPU.

10. The number of states may differ depending on the product. For details, refer to the relevant microcontroller hardware manual of the product in question.

(1) The number of states required for execution of an instruction that transfers data in synchronization with the E clock is variable.

(2) Set to 1 when a carry or borrow occurs at bit 27; otherwise cleared to 0.

(3) Set to 1 when a carry or borrow occurs at bit 11; otherwise cleared to 0.

(4) Retains its previous value when the result is zero; otherwise cleared to 0.

(5) Set to 1 when the divisor is negative; otherwise cleared to 0.

(6) Set to 1 when the divisor is zero; otherwise cleared to 0.

(7) Set to 1 when the quotient is negative; otherwise cleared to 0.

(8) MAC instruction results are indicated in the flags when the STMAC instruction is executed.

(9) One additional state is required for execution when EXR is valid.

## 2.4 Instruction Code

Table 2.2 Instruction Codes

| Instruction | Mnemonic           | Size | Instruction Format |          |             |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|-------------|--------------------|------|--------------------|----------|-------------|----------|-------------|----------|----------|----------|----------|-----------|--|--|--|--|--|--|--|--|
|             |                    |      | 1st byte           | 2nd byte | 3rd byte    | 4th byte | 5th byte    | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |  |  |  |  |  |  |  |  |
| ADD         | ADD.B #xx:8,Rd     | B    | 8                  | rd       | IMM         |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ADD.B Rs,Rd        | B    | 0                  | 8        | rs          | rd       |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ADD.W #xx:16,Rd    | W    | 7                  | 9        | 1           | rd       | IMM         |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ADD.W Rs,Rd        | W    | 0                  | 9        | rs          | rd       |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ADD.L #xx:32,ERd   | L    | 7                  | A        | 1           | 0:erd    |             |          |          | IMM      |          |           |  |  |  |  |  |  |  |  |
| ADDS        | ADD.L ERs,ERd      | L    | 0                  | A        | 1:ers;0:erd |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ADDS #1,ERd        | L    | 0                  | B        | 0           | 0:erd    |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ADDS #2,ERd        | L    | 0                  | B        | 8           | 0:erd    |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ADDS #4,ERd        | L    | 0                  | B        | 9           | 0:erd    |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ADDS #xx:8,Rd      | B    | 9                  | rd       | IMM         |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
| AND         | ADDX Rs,Rd         | B    | 0                  | E        | rs          | rd       |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | AND.B #xx:8,Rd     | B    | E                  | rd       | IMM         |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | AND.B Rs,Rd        | B    | 1                  | 6        | rs          | rd       |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | AND.W #xx:16,Rd    | W    | 7                  | 9        | 6           | rd       | IMM         |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | AND.W Rs,Rd        | W    | 6                  | 6        | rs          | rd       |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
| ANDC        | AND.L #xx:32,ERd   | L    | 7                  | A        | 6           | 0:erd    |             |          |          | IMM      |          |           |  |  |  |  |  |  |  |  |
|             | AND.L ERs,ERd      | L    | 0                  | 1        | F           | 0        | 6:ers;0:erd |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ANDC #xx:8,CCR     | B    | 0                  | 6        | IMM         |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ANDC #xx:8,EXR     | B    | 0                  | 1        | 4           | 1        | 0           | 6        | IMM      |          |          |           |  |  |  |  |  |  |  |  |
|             | BAND #xx:3,Rd      | B    | 7                  | 6        | 0:IMM;rd    |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BAND        | BAND #xx:3,@ERd    | B    | 7                  | C        | 0:erd;0     | 7        | 6           | 0:IMM;0  |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BAND #xx:3,@aa:8   | B    | 7                  | E        | abs         | 7        | 6           | 0:IMM;0  |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BAND #xx:3,@aa:16  | B    | 6                  | A        | 1           | 0        | abs         | 7        | 6        | 0:IMM;0  |          |           |  |  |  |  |  |  |  |  |
|             | BAND #xx:3,@aa:32  | B    | 6                  | A        | 3           | 0        | abs         | 7        | 6        | 0:IMM;0  |          |           |  |  |  |  |  |  |  |  |
|             | BRA d:8 (BT d:8)   | —    | 4                  | 0        | disp        |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
| Bcc         | BRA d:16 (BT d:16) | —    | 5                  | 8        | 0           | 0        | disp        |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BRN d:8 (BF d:8)   | —    | 4                  | 1        | disp        |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BRN d:16 (BF d:16) | —    | 5                  | 8        | 1           | 0        | disp        |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BHI d:8            | —    | 4                  | 2        | disp        |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BHI d:16           | —    | 5                  | 8        | 2           | 0        | disp        |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BLS         | BLS d:8            | —    | 4                  | 3        | disp        |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BLS d:16           | —    | 5                  | 8        | 3           | 0        | disp        |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BCC         | BCC d:8 (BHS d:8)  | —    | 4                  | 4        | disp        |          |             |          |          |          |          |           |  |  |  |  |  |  |  |  |

| Instruction | Mnemonic            | Size | Instruction Format |          |           |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|-------------|---------------------|------|--------------------|----------|-----------|----------|----------|----------|----------|----------|----------|-----------|--|--|--|--|--|--|--|--|--|
|             |                     |      | 1st byte           | 2nd byte | 3rd byte  | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |  |  |  |  |  |  |  |  |  |
| Bcc         | BCC d:16 (BHS d:16) | —    | 5                  | 8        | 4         | 0        | disp     |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BCS d:8 (BLO d:8)   | —    | 4                  | 5        | disp      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BCS d:16 (BLO d:16) | —    | 5                  | 8        | 5         | 0        | disp     |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BNE d:8             | —    | 4                  | 6        | disp      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BNE d:16            | —    | 5                  | 8        | 6         | 0        | disp     |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BEQ d:8             | —    | 4                  | 7        | disp      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BEQ d:16            | —    | 5                  | 8        | 7         | 0        | disp     |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BVC d:8             | —    | 4                  | 8        | disp      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BVC d:16            | —    | 5                  | 8        | 8         | 0        | disp     |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BVS d:8             | —    | 4                  | 9        | disp      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BVS d:16            | —    | 5                  | 8        | 9         | 0        | disp     |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BPL d:8             | —    | 4                  | A        | disp      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BPL d:16            | —    | 5                  | 8        | A         | 0        | disp     |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BMI d:8             | —    | 4                  | B        | disp      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BMI d:16            | —    | 5                  | 8        | B         | 0        | disp     |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BGE d:8             | —    | 4                  | C        | disp      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
| BGE d:16    | —                   | 5    | 8                  | C        | 0         | disp     |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
| BLT d:8     | —                   | 4    | D                  | disp     |           |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
| BLT d:16    | —                   | 5    | 8                  | D        | 0         | disp     |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
| BGT d:8     | —                   | 4    | E                  | disp     |           |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
| BGT d:16    | —                   | 5    | 8                  | E        | 0         | disp     |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
| BLE d:8     | —                   | 4    | F                  | disp     |           |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
| BLE d:16    | —                   | 5    | 8                  | F        | 0         | disp     |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
| BCLR        | BCLR #xx:3,Rd       | B    | 7                  | 2        | 0:IMM: rd |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BCLR #xx:3,@ERd     | B    | 7                  | D        | 0:erd: 0  | 7        | 2        | 0:IMM: 0 |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BCLR #xx:3,@aa:8    | B    | 7                  | F        | abs       | 7        | 2        | 0:IMM: 0 |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BCLR #xx:3,@aa:16   | B    | 6                  | A        | 1         | 8        | abs      | 7        | 2        | 0:IMM: 0 |          |           |  |  |  |  |  |  |  |  |  |
|             | BCLR #xx:3@aa:32    | B    | 6                  | A        | 3         | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BCLR Rn,Rd          | B    | 6                  | 2        | rn        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BCLR Rn,@ERd        | B    | 7                  | D        | 0:erd: 0  | 6        | 2        | rn       | 0        |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BCLR Rn,@aa:8       | B    | 7                  | F        | abs       | 6        | 2        | rn       | 0        |          |          |           |  |  |  |  |  |  |  |  |  |
|             | BCLR Rn,@aa:16      | B    | 6                  | A        | 1         | 8        | abs      | 6        | 2        | rn       | 0        |           |  |  |  |  |  |  |  |  |  |
|             | BCLR Rn,@aa:32      | B    | 6                  | A        | 3         | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |  |



| Instruction | Mnemonic           | Size | Instruction Format |          |           |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|-------------|--------------------|------|--------------------|----------|-----------|----------|----------|----------|----------|----------|----------|-----------|--|--|--|--|--|--|--|--|
|             |                    |      | 1st byte           | 2nd byte | 3rd byte  | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |  |  |  |  |  |  |  |  |
| BIAND       | BIAND #xx:3,Rd     | B    | 7                  | 6        | 1:IMM; rd |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIAND #xx:3,@ERd   | B    | 7                  | C        | 0:erd; 0  | 7        | 6        | 1:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIAND #xx:3,@aa8   | B    | 7                  | E        | abs       | 7        | 6        | 1:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIAND #xx:3,@aa:16 | B    | 6                  | A        | 1         | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIAND #xx:3,@aa:32 | B    | 6                  | A        | 3         | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BILD        | BILD #xx:3,Rd      | B    | 7                  | 7        | 1:IMM; rd |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BILD #xx:3,@ERd    | B    | 7                  | C        | 0:erd; 0  | 7        | 7        | 1:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BILD #xx:3,@aa8    | B    | 7                  | E        | abs       | 7        | 7        | 1:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BILD #xx:3,@aa:16  | B    | 6                  | A        | 1         | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BILD #xx:3,@aa:32  | B    | 6                  | A        | 3         | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BIOR        | BIOR #xx:3,Rd      | B    | 7                  | 4        | 1:IMM; rd |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIOR #xx:3,@ERd    | B    | 7                  | C        | 0:erd; 0  | 7        | 4        | 1:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIOR #xx:3,@aa8    | B    | 7                  | E        | abs       | 7        | 4        | 1:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIOR #xx:3,@aa:16  | B    | 6                  | A        | 1         | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIOR #xx:3,@aa:32  | B    | 6                  | A        | 3         | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BIST        | BIST #xx:3,Rd      | B    | 6                  | 7        | 1:IMM; rd |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIST #xx:3,@ERd    | B    | 7                  | D        | 0:erd; 0  | 6        | 7        | 1:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIST #xx:3,@aa8    | B    | 7                  | F        | abs       | 6        | 7        | 1:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIST #xx:3,@aa:16  | B    | 6                  | A        | 1         | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIST #xx:3,@aa:32  | B    | 6                  | A        | 3         | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BIXOR       | BIXOR #xx:3,Rd     | B    | 7                  | 5        | 1:IMM; rd |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIXOR #xx:3,@ERd   | B    | 7                  | C        | 0:erd; 0  | 7        | 5        | 1:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIXOR #xx:3,@aa8   | B    | 7                  | E        | abs       | 7        | 5        | 1:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIXOR #xx:3,@aa:16 | B    | 6                  | A        | 1         | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BIXOR #xx:3,@aa:32 | B    | 6                  | A        | 3         | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BLD         | BLD #xx:3,Rd       | B    | 7                  | 7        | 0:IMM; rd |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BLD #xx:3,@ERd     | B    | 7                  | C        | 0:erd; 0  | 7        | 7        | 0:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BLD #xx:3,@aa8     | B    | 7                  | E        | abs       | 7        | 7        | 0:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BLD #xx:3,@aa:16   | B    | 6                  | A        | 1         | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BLD #xx:3,@aa:32   | B    | 6                  | A        | 3         | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BNOT        | BNOT #xx:3,Rd      | B    | 7                  | 1        | 0:IMM; rd |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BNOT #xx:3,@ERd    | B    | 7                  | D        | 0:erd; 0  | 7        | 1        | 0:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BNOT #xx:3,@aa:8   | B    | 7                  | F        | abs       | 7        | 1        | 0:IMM; 0 |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BNOT #xx:3,@aa:16  | B    | 6                  | A        | 1         | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BNOT #xx:3,@aa:32  | B    | 6                  | A        | 3         | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BNOT Rn,Rd  | B                  | 6    | 1                  | rn rd    |           |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |

| Instruction | Mnemonic          | Size | Instruction Format |          |          |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|-------------|-------------------|------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|--|--|--|--|--|--|--|--|
|             |                   |      | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |  |  |  |  |  |  |  |  |
| BNOT        | BNOT Rn,@ERd      | B    | 7                  | D        | 0:erd    | 0        | 6        | 1        | rn       | 0        |          |           |  |  |  |  |  |  |  |  |
|             | BNOT Rn,@aa:8     | B    | 7                  | F        | abs      | 6        | 1        | rn       | 0        |          |          |           |  |  |  |  |  |  |  |  |
|             | BNOT Rn,@aa:16    | B    | 6                  | A        | 1        | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BNOT Rn,@aa:32    | B    | 6                  | A        | 3        | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BOR #xx:3,Rd      | B    | 7                  | 4        | 0:IMM    | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BOR         | BOR #xx:3,@ERd    | B    | 7                  | C        | 0:erd    | 0        | 7        | 4        | 0:IMM    | 0        |          |           |  |  |  |  |  |  |  |  |
|             | BOR #xx:3,@aa:8   | B    | 7                  | E        | abs      | 7        | 4        | 0:IMM    | 0        |          |          |           |  |  |  |  |  |  |  |  |
|             | BOR #xx:3,@aa:16  | B    | 6                  | A        | 1        | 0        | abs #+1  |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BOR #xx:3,@aa:32  | B    | 6                  | A        | 3        | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BSET #xx:3,Rd     | B    | 7                  | 0        | 0:IMM    | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BSET        | BSET #xx:3,@ERd   | B    | 7                  | D        | 0:erd    | 0        | 7        | 0        | 0:IMM    | 0        |          |           |  |  |  |  |  |  |  |  |
|             | BSET #xx:3,@aa:8  | B    | 7                  | F        | abs      | 7        | 0        | 0:IMM    | 0        |          |          |           |  |  |  |  |  |  |  |  |
|             | BSET #xx:3,@aa:16 | B    | 6                  | A        | 1        | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BSET #xx:3,@aa:32 | B    | 6                  | A        | 3        | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BSET Rn,Rd        | B    | 6                  | A        | 3        | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BSET Rn,@ERd      | B    | 7                  | D        | 0:erd    | 0        | 6        | 0        | rn       | 0        |          |           |  |  |  |  |  |  |  |  |
|             | BSET Rn,@aa:8     | B    | 7                  | F        | abs      | 6        | 0        | rn       | 0        |          |          |           |  |  |  |  |  |  |  |  |
|             | BSET Rn,@aa:16    | B    | 6                  | A        | 1        | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BSET Rn,@aa:32    | B    | 6                  | A        | 3        | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BSR d:8           | —    | 5                  | 5        | disp     |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| BST         | BST #xx:3,Rd      | B    | 6                  | 7        | 0:IMM    | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BST #xx:3,@ERd    | B    | 7                  | D        | 0:erd    | 0        | 6        | 7        | 0:IMM    | 0        |          |           |  |  |  |  |  |  |  |  |
|             | BST #xx:3,@aa:8   | B    | 7                  | F        | abs      | 6        | 7        | 0:IMM    | 0        |          |          |           |  |  |  |  |  |  |  |  |
|             | BST #xx:3,@aa:16  | B    | 6                  | A        | 1        | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BST #xx:3,@aa:32  | B    | 6                  | A        | 3        | 8        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BTST #xx:3,Rd     | B    | 7                  | 3        | 0:IMM    | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BTST #xx:3,@ERd   | B    | 7                  | C        | 0:erd    | 0        | 7        | 3        | 0:IMM    | 0        |          |           |  |  |  |  |  |  |  |  |
| BTST        | BTST #xx:3,@aa:8  | B    | 7                  | E        | abs      | 7        | 3        | 0:IMM    | 0        |          |          |           |  |  |  |  |  |  |  |  |
|             | BTST #xx:3,@aa:16 | B    | 6                  | A        | 1        | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BTST #xx:3,@aa:32 | B    | 6                  | A        | 3        | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BTST Rn,Rd        | B    | 6                  | 3        | rn       | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | BTST Rn,@ERd      | B    | 7                  | C        | 0:erd    | 0        | 6        | 3        | rn       | 0        |          |           |  |  |  |  |  |  |  |  |
|             | BTST Rn,@aa:8     | B    | 7                  | E        | abs      | 6        | 3        | rn       | 0        |          |          |           |  |  |  |  |  |  |  |  |
|             | BTST Rn,@aa:16    | B    | 6                  | A        | 1        | 0        | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |

| Instruction | Mnemonic          | Size           | Instruction Format |          |          |          |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|-------------|-------------------|----------------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|-------|---|---|---|-------|---|--|--|--|
|             |                   |                | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |       |   |   |   |       |   |  |  |  |
| BXOR        | BXOR #xx:3,Rd     | B              | 7                  | 5        | 0:IMM    | rd       |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | BXOR #xx:3,@ERd   | B              | 7                  | C        | 0:erd    | 0        | 7        | 5        | 0:IMM    | 0        |          |           |       |   |   |   |       |   |  |  |  |
|             | BXOR #xx:3,@aa:8  | B              | 7                  | E        | abs      |          | 7        | 5        | 0:IMM    | 0        |          |           |       |   |   |   |       |   |  |  |  |
|             | BXOR #xx:3,@aa:16 | B              | 6                  | A        | 1        | 0        |          |          | abs      |          | 7        | 5         | 0:IMM | 0 |   |   |       |   |  |  |  |
|             | BXOR #xx:3,@aa:32 | B              | 6                  | A        | 3        | 0        |          |          | abs      |          |          |           |       |   | 7 | 5 | 0:IMM | 0 |  |  |  |
| CLRMAC*1    | CLRMAC            | —              | 0                  | 1        | A        | 0        |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
| CMP         | CMPB #x:8,Rd      | B              | A                  | rd       | IMM      |          |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | CMPB Rs,Rd        | B              | 1                  | C        | rs       | rd       |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | CMPW #x:16,Rd     | W              | 7                  | 9        | 2        | rd       |          |          | IMM      |          |          |           |       |   |   |   |       |   |  |  |  |
|             | CMPW Rd,Rd        | W              | 1                  | D        | rs       | rd       |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | CMPL #x:32,ERd    | L              | 7                  | A        | 2        | 0:erd    |          |          |          | IMM      |          |           |       |   |   |   |       |   |  |  |  |
| DAA         | CMPL ERs,ERd      | L              | 1                  | F        | 1:ens    | 0:erd    |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | DAA Rd            | B              | 0                  | F        | 0        | rd       |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | DAS Rd            | B              | 1                  | F        | 0        | rd       |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | DEC               | DECB Rd        | B                  | 1        | A        | 0        | rd       |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             |                   | DECW #1,Rd     | W                  | 1        | B        | 5        | rd       |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             |                   | DECW #2,Rd     | W                  | 1        | B        | D        | rd       |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | DIVXS             | DECL #1,ERd    | L                  | 1        | B        | 7        | 0:erd    |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             |                   | DECL #2,ERd    | L                  | 1        | B        | F        | 0:erd    |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             |                   | DIVXS B Rs,ERd | B                  | 0        | 1        | D        | 0        | 5        | 1        | rs       | rd       |           |       |   |   |   |       |   |  |  |  |
|             |                   | DIVXS W Rs,ERd | W                  | 0        | 1        | D        | 0        | 5        | 3        | rs       | 0:erd    |           |       |   |   |   |       |   |  |  |  |
|             |                   | DIVXU B Rs,Rd  | B                  | 5        | 1        | rs       | rd       |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | EEMOV             | DIVXU W Rs,ERd | W                  | 5        | 3        | rs       | 0:erd    |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             |                   | EEMOV B        | —                  | 7        | B        | 5        | C        | 5        | 9        | 8        | F        |           |       |   |   |   |       |   |  |  |  |
| EEMOV W     |                   | —              | 7                  | B        | D        | 4        | 5        | 9        | 8        | F        |          |           |       |   |   |   |       |   |  |  |  |
| EXTS        | EXTS W Rd         | W              | 1                  | 7        | D        | rd       |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | EXTS L ERd        | L              | 1                  | 7        | F        | 0:erd    |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
| EXTU        | EXTU W Rd         | W              | 1                  | 7        | 5        | rd       |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | EXTU L ERd        | L              | 1                  | 7        | 7        | 0:erd    |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | INCB Rd           | B              | 0                  | A        | 0        | rd       |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
| INC         | INC W #1,Rd       | W              | 0                  | B        | 5        | rd       |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | INC W #2,Rd       | W              | 0                  | B        | D        | rd       |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | INCL #1,ERd       | L              | 0                  | B        | 7        | 0:erd    |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |
|             | INCL #2,ERd       | L              | 0                  | B        | F        | 0:erd    |          |          |          |          |          |           |       |   |   |   |       |   |  |  |  |

| Instruction | Mnemonic               | Size | Instruction Format |          |          |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|-------------|------------------------|------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|--|--|--|--|--|--|--|--|
|             |                        |      | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |  |  |  |  |  |  |  |  |
| JMP         | JMP @ERn               | —    | 5                  | 9        | 0:ern    | 0        |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | JMP @aa:24             | —    | 5                  | A        |          | abs      |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| JSR         | JMP @aa:8              | —    | 5                  | B        | abs      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | JSR @ERn               | —    | 5                  | D        | 0:ern    | 0        |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| JSR         | JSR @aa:24             | —    | 5                  | E        |          | abs      |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | JSR @aa:8              | —    | 5                  | F        | abs      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| LDC         | LDC #xx:8,CCR          | B    | 0                  | 7        | IMM      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | LDC #xx:8,EXR          | B    | 0                  | 1        | 4        | 1        | 0        | 7        | IMM      |          |          |           |  |  |  |  |  |  |  |  |
|             | LDC Rs,CCR             | B    | 0                  | 3        | 0        | rs       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | LDC Rs,EXR             | B    | 0                  | 3        | 1        | rs       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | LDC @ERs,CCR           | W    | 0                  | 1        | 4        | 0        | 6        | 9        | 0:ers    | 0        |          |           |  |  |  |  |  |  |  |  |
|             | LDC @ERs,EXR           | W    | 0                  | 1        | 4        | 1        | 6        | 9        | 0:ers    | 0        |          |           |  |  |  |  |  |  |  |  |
|             | LDC @(d:16,ERs),CCR    | W    | 0                  | 1        | 4        | 0        | 6        | F        | 0:ers    | 0        | disp     |           |  |  |  |  |  |  |  |  |
|             | LDC @(d:16,ERs),EXR    | W    | 0                  | 1        | 4        | 1        | 6        | F        | 0:ers    | 0        | disp     |           |  |  |  |  |  |  |  |  |
|             | LDC @(d:32,ERs),CCR    | W    | 0                  | 1        | 4        | 0        | 7        | 8        | 0:ers    | 0        | disp     |           |  |  |  |  |  |  |  |  |
|             | LDC @(d:32,ERs),EXR    | W    | 0                  | 1        | 4        | 1        | 7        | 8        | 0:ers    | 0        | disp     |           |  |  |  |  |  |  |  |  |
| LDM         | LDC @ERs+,CCR          | W    | 0                  | 1        | 4        | 0        | 6        | D        | 0:ers    | 0        |          |           |  |  |  |  |  |  |  |  |
|             | LDC @ERs+,EXR          | W    | 0                  | 1        | 4        | 1        | 6        | D        | 0:ers    | 0        |          |           |  |  |  |  |  |  |  |  |
|             | LDC @aa:16,CCR         | W    | 0                  | 1        | 4        | 0        | 6        | B        | 0        | 0        | abs      |           |  |  |  |  |  |  |  |  |
|             | LDC @aa:16,EXR         | W    | 0                  | 1        | 4        | 1        | 6        | B        | 0        | 0        | abs      |           |  |  |  |  |  |  |  |  |
|             | LDC @aa:32,CCR         | W    | 0                  | 1        | 4        | 0        | 6        | B        | 2        | 0        | abs      |           |  |  |  |  |  |  |  |  |
|             | LDC @aa:32,EXR         | W    | 0                  | 1        | 4        | 1        | 6        | B        | 2        | 0        | abs      |           |  |  |  |  |  |  |  |  |
|             | LDM.L @SP+,(ERn-ERn+1) | L    | 0                  | 1        | 1        | 0        | 6        | D        | 7        | 0:erm+1  |          |           |  |  |  |  |  |  |  |  |
|             | LDM.L @SP+,(ERn-ERn+2) | L    | 0                  | 1        | 2        | 0        | 6        | D        | 7        | 0:erm+2  |          |           |  |  |  |  |  |  |  |  |
|             | LDM.L @SP+,(ERn-ERn+3) | L    | 0                  | 1        | 3        | 0        | 6        | D        | 7        | 0:erm+3  |          |           |  |  |  |  |  |  |  |  |
|             | LDMAC ERs,MACH         | L    | 0                  | 3        | 2        | 0:ers    |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| MAC*1       | LDMAC ERs,MACL         | L    | 0                  | 3        | 3        | 0:ers    |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | MAC @ERn+,@ERm+        | —    | 0                  | 1        | 6        | 0        | 6        | D        | 0:ern    | 0:erm    |          |           |  |  |  |  |  |  |  |  |
| MOV         | MOV.B #xx:8,Rd         | B    | F                  | rd       | IMM      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | MOV.B Rs,Rd            | B    | 0                  | C        | rs       | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | MOV.B @ERs,Rd          | B    | 6                  | 8        | 0:ers    | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | MOV.B @(d:16,ERs),Rd   | B    | 6                  | E        | 0:ers    | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | MOV.B @(d:32,ERs),Rd   | B    | 7                  | 8        | 0:ers    | 0        | 6        | A        | 2        | rd       | disp     |           |  |  |  |  |  |  |  |  |
|             | MOV.B @ERs+,Rd         | B    | 6                  | C        | 0:ers    | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | MOV.B @aa:8,Rd         | B    | 2                  | rd       | abs      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | MOV.B @aa:16,Rd        | B    | 6                  | A        | 0        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |

| Instruction                           | Mnemonic              | Size | Instruction Format |          |          |          |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
|---------------------------------------|-----------------------|------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|-------|------|--|--|--|--|--|--|--|
|                                       |                       |      | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |       |      |  |  |  |  |  |  |  |
| MOV                                   | MOV.B @aa:32,Rd       | B    | 6                  | A        | 2        | rd       |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.B Rs,@ERd         | B    | 6                  | 8        | 1:erd    | rs       |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.B Rs,@(d:16,ERd)  | B    | 6                  | E        | 1:erd    | rs       |          |          | disp     |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.B Rs,@(r:32,ERd)  | B    | 7                  | 8        | 0:erd    | 0        | 6        | A        | A        | rs       |          |           |       | disp |  |  |  |  |  |  |  |
|                                       | MOV.B Rs,@-ERd        | B    | 6                  | C        | 1:erd    | rs       |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.B Rs,@aa:8        | B    | 3                  | rs       |          | abs      |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.B Rs,@aa:16       | B    | 6                  | A        | 8        | rs       |          |          | abs      |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.B Rs,@aa:32       | B    | 6                  | A        | A        | rs       |          |          | abs      |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.W #xx:16,Rd       | W    | 7                  | 9        | 0        | rd       |          |          |          | IMM      |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.W Rs,Rd           | W    | 0                  | D        | rs       | rd       |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.W @ERSs,Rd        | W    | 6                  | 9        | 0:ers    | rd       |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.W @(d:16,ERSs),Rd | W    | 6                  | F        | 0:ers    | rd       |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.W @(d:32,ERSs),Rd | W    | 7                  | 8        | 0:ers    | 0        | 6        | B        | 2        | rd       |          |           |       | disp |  |  |  |  |  |  |  |
|                                       | MOV.W @ERSs+,Rd       | W    | 6                  | D        | 0:ers    | rd       |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.W @aa:16,Rd       | W    | 6                  | B        | 0        | rd       |          |          |          | abs      |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.W @aa:32,Rd       | W    | 6                  | B        | 2        | rd       |          |          |          | abs      |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.W Rs,@ERd         | W    | 6                  | 9        | 1:erd    | rs       |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.W Rs,@(d:16,ERd)  | W    | 6                  | F        | 1:erd    | rs       |          |          |          | disp     |          |           |       |      |  |  |  |  |  |  |  |
|                                       | MOV.W Rs,@(d:32,ERd)  | W    | 7                  | 8        | 0:erd    | 0        | 6        | B        | A        | rs       |          |           |       | disp |  |  |  |  |  |  |  |
|                                       | MOV.W Rs,@-ERd        | W    | 6                  | D        | 1:erd    | rs       |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
| MOV.W Rs,@aa:16                       | W                     | 6    | B                  | 8        | rs       |          |          |          | abs      |          |          |           |       |      |  |  |  |  |  |  |  |
| MOV.W Rs,@aa:32                       | W                     | 6    | B                  | A        | rs       |          |          |          | abs      |          |          |           |       |      |  |  |  |  |  |  |  |
| MOV.L #xx:32,Rd                       | L                     | 7    | A                  | 0        | 0:erd    |          |          |          | IMM      |          |          |           |       |      |  |  |  |  |  |  |  |
| MOV.L ERSs,ERd                        | L                     | 0    | F                  | 1:ers    | 0:erd    |          |          |          |          |          |          |           |       |      |  |  |  |  |  |  |  |
| MOV.L @ERSs,ERd                       | L                     | 0    | 1                  | 0        | 0        | 6        | 9        | 0:ers    | 0:erd    |          |          |           |       |      |  |  |  |  |  |  |  |
| MOV.L @(d:16,ERSs),ERd                | L                     | 0    | 1                  | 0        | 0        | 6        | F        | 0:ers    | 0:erd    |          |          |           | disp  |      |  |  |  |  |  |  |  |
| MOV.L @(d:32,ERSs),ERd                | L                     | 0    | 1                  | 0        | 0        | 7        | 8        | 0:ers    | 0        | 6        | 2        | 0:erd     |       |      |  |  |  |  |  |  |  |
| MOV.L @ERSs+,ERd                      | L                     | 0    | 1                  | 0        | 0        | 6        | D        | 0:ers    | 0:erd    |          |          |           |       |      |  |  |  |  |  |  |  |
| MOV.L @aa:16,ERd                      | L                     | 0    | 1                  | 0        | 0        | 6        | B        | 0        | 0:erd    |          |          |           | abs   |      |  |  |  |  |  |  |  |
| MOV.L @aa:32,ERd                      | L                     | 0    | 1                  | 0        | 0        | 6        | B        | 2        | 0:erd    |          |          |           | abs   |      |  |  |  |  |  |  |  |
| MOV.L ERSs,@ERd                       | L                     | 0    | 1                  | 0        | 0        | 6        | 9        | 1:erd    | 0:ers    |          |          |           |       |      |  |  |  |  |  |  |  |
| MOV.L ERSs,@(d:16,ERd) <sup>1</sup>   | L                     | 0    | 1                  | 0        | 0        | 6        | F        | 1:erd    | 0:ers    |          |          |           | disp  |      |  |  |  |  |  |  |  |
| MOV.L ERSs,@(d:32,ERd) <sup>1,2</sup> | L                     | 0    | 1                  | 0        | 0        | 7        | 8        | 0:erd    | 0        | 6        | 2        | A         | 0:ers |      |  |  |  |  |  |  |  |
| MOV.L ERSs,@-ERd                      | L                     | 0    | 1                  | 0        | 0        | 6        | D        | 1:erd    | 0:ers    |          |          |           |       |      |  |  |  |  |  |  |  |
| MOV.L ERSs,@aa:16                     | L                     | 0    | 1                  | 0        | 0        | 6        | B        | 8        | 0:ers    |          |          |           | abs   |      |  |  |  |  |  |  |  |
| MOV.L ERSs,@aa:32                     | L                     | 0    | 1                  | 0        | 0        | 6        | B        | A        | 0:ers    |          |          |           | abs   |      |  |  |  |  |  |  |  |

| Instruction | Mnemonic        | Size | Instruction Format |          |          |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|-------------|-----------------|------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|--|--|--|--|--|--|--|--|
|             |                 |      | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |  |  |  |  |  |  |  |  |
| MOVFP       | MOVFP @aa:16,Rd | B    | 6                  | A        | 4        | rd       | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
| MOVTP       | MOVTP Rs,@aa:16 | B    | 6                  | A        | C        | rs       | abs      |          |          |          |          |           |  |  |  |  |  |  |  |  |
| MULXS       | MULXS.B Rs,Rd   | B    | 0                  | 1        | C        | 0        | 5        | 0        | rs       | rd       |          |           |  |  |  |  |  |  |  |  |
|             | MULXS.W Rs,Rd   | W    | 0                  | 1        | C        | 0        | 5        | 2        | rs       | 0:erd    |          |           |  |  |  |  |  |  |  |  |
| MULXU       | MULXU.B Rs,Rd   | B    | 5                  | 0        | rs       | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | MULXU.W Rs,Rd   | W    | 5                  | 2        | rs       | 0:erd    |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| NEG         | NEG.B Rd        | B    | 1                  | 7        | 8        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | NEG.W Rd        | W    | 1                  | 7        | 9        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | NEG.L ERd       | L    | 1                  | 7        | B        | 0:erd    |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| NOP         | NOP             | —    | 0                  | 0        | 0        | 0        |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| NOT         | NOT.B Rd        | B    | 1                  | 7        | 0        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | NOT.W Rd        | W    | 1                  | 7        | 1        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | NOT.L ERd       | L    | 1                  | 7        | 3        | 0:erd    |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| OR          | OR.B #xx:8,Rd   | B    | C                  | rd       | IMM      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | OR.B Rs,Rd      | B    | 1                  | 4        | rs       | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | OR.W #xx:16,Rd  | W    | 7                  | 9        | 4        | rd       | IMM      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | OR.W Rs,Rd      | W    | 6                  | 4        | rs       | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | OR.L #xx:32,ERd | L    | 7                  | A        | 4        | 0:erd    | IMM      |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | OR.L ERs,ERd    | L    | 0                  | 1        | F        | 0        | 6        | 4        | 0:ers    | 0:erd    |          |           |  |  |  |  |  |  |  |  |
| ORC         | ORC #xx:8,CCR   | B    | 0                  | 4        | IMM      |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ORC #xx:8,EXR   | B    | 0                  | 1        | 4        | 1        | 0        | 4        | IMM      |          |          |           |  |  |  |  |  |  |  |  |
| POP         | POP.W Rn        | W    | 6                  | D        | 7        | rn       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | POP.L ERn       | L    | 0                  | 1        | 0        | 0        | 6        | D        | 7        | 0:ern    |          |           |  |  |  |  |  |  |  |  |
| PUSH        | PUSH.W Rn       | W    | 6                  | D        | F        | rn       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | PUSH.L ERn      | L    | 0                  | 1        | 0        | 0        | 6        | D        | F        | 0:ern    |          |           |  |  |  |  |  |  |  |  |
| ROTL        | ROTL.B Rd       | B    | 1                  | 2        | 8        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ROTL.B #2,Rd    | B    | 1                  | 2        | C        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ROTL.W Rd       | W    | 1                  | 2        | 9        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ROTL.W #2,Rd    | W    | 1                  | 2        | D        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ROTL.L ERd      | L    | 1                  | 2        | B        | 0:erd    |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ROTL.L #2,ERd   | L    | 1                  | 2        | F        | 0:erd    |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| ROTR        | ROTR.B Rd       | B    | 1                  | 3        | 8        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ROTR.B #2,Rd    | B    | 1                  | 3        | C        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ROTR.W Rd       | W    | 1                  | 3        | 9        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|             | ROTR.W #2,Rd    | W    | 1                  | 3        | D        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |

| Instruction  | Mnemonic       | Size | Instruction Format |          |          |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|--------------|----------------|------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|--|--|--|--|--|--|--|--|
|              |                |      | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |  |  |  |  |  |  |  |  |
| ROTR         | ROTR.L ERd     | L    | 1                  | 3        | B        | 0        | : erd    |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | ROTR.L #2,ERd  | L    | 1                  | 3        | F        | 0        | : erd    |          |          |          |          |           |  |  |  |  |  |  |  |  |
| ROTXL        | ROTXL.B Rd     | B    | 1                  | 2        | 0        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | ROTXL.B #2,Rd  | B    | 1                  | 2        | 4        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | ROTXL.W Rd     | W    | 1                  | 2        | 1        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | ROTXL.W #2,Rd  | W    | 1                  | 2        | 5        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | ROTXL.L ERd    | L    | 1                  | 2        | 3        | 0: erd   |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | ROTXL.L #2,ERd | L    | 1                  | 2        | 7        | 0: erd   |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| ROTXR        | ROTXR.B Rd     | B    | 1                  | 3        | 0        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | ROTXR.B #2,Rd  | B    | 1                  | 3        | 4        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | ROTXR.W Rd     | W    | 1                  | 3        | 1        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | ROTXR.W #2,Rd  | W    | 1                  | 3        | 5        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | ROTXR.L ERd    | L    | 1                  | 3        | 3        | 0: erd   |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | ROTXR.L #2,ERd | L    | 1                  | 3        | 7        | 0: erd   |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| RTE          | RTE            | —    | 5                  | 6        | 7        | 0        |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| RTS          | RTS            | —    | 5                  | 4        | 7        | 0        |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHAL.B Rd      | B    | 1                  | 0        | 8        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| SHAL         | SHAL.B #2,Rd   | B    | 1                  | 0        | C        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHAL.W Rd      | W    | 1                  | 0        | 9        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHAL.W #2,Rd   | W    | 1                  | 0        | D        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHALL.ERd      | L    | 1                  | 0        | B        | 0: erd   |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHALL.#2,ERd   | L    | 1                  | 0        | F        | 0: erd   |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHAR.B Rd      | B    | 1                  | 1        | 8        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| SHAR         | SHAR.B #2,Rd   | B    | 1                  | 1        | C        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHAR.W Rd      | W    | 1                  | 1        | 9        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHAR.W #2,Rd   | W    | 1                  | 1        | D        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHAR.L ERd     | L    | 1                  | 1        | B        | 0: erd   |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHAR.L #2,ERd  | L    | 1                  | 1        | F        | 0: erd   |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHLL.B Rd      | B    | 1                  | 0        | 0        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| SHLL         | SHLL.B #2,Rd   | B    | 1                  | 0        | 4        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHLL.W Rd      | W    | 1                  | 0        | 1        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHLL.W #2,Rd   | W    | 1                  | 0        | 5        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHLL.L ERd     | L    | 1                  | 0        | 3        | 0: erd   |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHLL.L #2,ERd  | L    | 1                  | 0        | 7        | 0: erd   |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
|              | SHLR.B Rd      | B    | 1                  | 1        | 0        | rd       |          |          |          |          |          |           |  |  |  |  |  |  |  |  |
| SHLR.B #2,Rd | B              | 1    | 1                  | 4        | rd       |          |          |          |          |          |          |           |  |  |  |  |  |  |  |  |

| Instruction      | Mnemonic               | Size | Instruction Format |          |          |          |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|------------------|------------------------|------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|---|---|--|--|--|--|--|------|
|                  |                        |      | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |   |   |  |  |  |  |  |      |
| SHLR             | SHLR.W.Rd              | W    | 1                  | 1        | rd       |          |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | SHLR.W.#2.Rd           | W    | 1                  | 1        | 5        | rd       |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | SHLR.L.ERd             | L    | 1                  | 1        | 3        | 0:erd    |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | SHLR.L.#2.ERd          | L    | 1                  | 1        | 7        | 0:erd    |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
| SLEEP            | SLEEP                  | —    | 0                  | 1        | 8        | 0        |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
| STC              | STC.B.CCR.Rd           | B    | 0                  | 2        | 0        | rd       |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | STC.B.EXR.Rd           | B    | 0                  | 2        | 1        | rd       |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | STC.W.CCR.@ERd         | W    | 0                  | 1        | 4        | 0        | 6        | 9        | 1:erd    | 0        |          |           |   |   |  |  |  |  |  |      |
|                  | STC.W.EXR.@ERd         | W    | 0                  | 1        | 4        | 1        | 6        | 9        | 1:erd    | 0        |          |           |   |   |  |  |  |  |  |      |
|                  | STC.W.CCR.@(d:16.ERd)  | W    | 0                  | 1        | 4        | 0        | 6        | F        | 1:erd    | 0        | disp     |           |   |   |  |  |  |  |  |      |
|                  | STC.W.EXR.@(d:16.ERd)  | W    | 0                  | 1        | 4        | 1        | 6        | F        | 1:erd    | 0        | disp     |           |   |   |  |  |  |  |  |      |
|                  | STC.W.CCR.@(d:32.ERd)  | W    | 0                  | 1        | 4        | 0        | 7        | 8        | 0:erd    | 0        | 6        | B         | A | 0 |  |  |  |  |  | disp |
|                  | STC.W.EXR.@(d:32.ERd)  | W    | 0                  | 1        | 4        | 1        | 7        | 8        | 0:erd    | 0        | 6        | B         | A | 0 |  |  |  |  |  | disp |
|                  | STC.W.CCR.@-ERd        | W    | 0                  | 1        | 4        | 0        | 6        | D        | 1:erd    | 0        |          |           |   |   |  |  |  |  |  |      |
|                  | STC.W.EXR.@-ERd        | W    | 0                  | 1        | 4        | 1        | 6        | D        | 1:erd    | 0        |          |           |   |   |  |  |  |  |  |      |
|                  | STC.W.CCR.@aa:16       | W    | 0                  | 1        | 4        | 0        | 6        | B        | 8        | 0        | abs      |           |   |   |  |  |  |  |  |      |
| STC.W.EXR.@aa:16 | W                      | 0    | 1                  | 4        | 1        | 6        | B        | 8        | 0        | abs      |          |           |   |   |  |  |  |  |  |      |
| STC.W.CCR.@aa:32 | W                      | 0    | 1                  | 4        | 0        | 6        | B        | A        | 0        | abs      |          |           |   |   |  |  |  |  |  |      |
| STC.W.EXR.@aa:32 | W                      | 0    | 1                  | 4        | 1        | 6        | B        | A        | 0        | abs      |          |           |   |   |  |  |  |  |  |      |
| STM              | STMLL (ERn-ERn+1).@-SP | L    | 0                  | 1        | 1        | 0        | 6        | D        | F        | 0:ern    |          |           |   |   |  |  |  |  |  |      |
|                  | STMLL (ERn-ERn+2).@-SP | L    | 0                  | 1        | 2        | 0        | 6        | D        | F        | 0:ern    |          |           |   |   |  |  |  |  |  |      |
|                  | STMLL (ERn-ERn+3).@-SP | L    | 0                  | 1        | 3        | 0        | 6        | D        | F        | 0:ern    |          |           |   |   |  |  |  |  |  |      |
|                  | STMACHL.ERd            | L    | 0                  | 2        | 2        | 0:ers    |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | STMACHL.ERd            | L    | 0                  | 2        | 3        | 0:ers    |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | SUBB.Rs.Rd             | B    | 1                  | 8        | rs       | rd       |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
| SUB              | SUB.W.#xx:16.Rd        | W    | 7                  | 9        | 3        | rd       |          |          |          | IMM      |          |           |   |   |  |  |  |  |  |      |
|                  | SUB.W.Rs.Rd            | W    | 1                  | 9        | rs       | rd       |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | SUB.L.#xx:32.ERd       | L    | 7                  | A        | 3        | 0:erd    |          |          |          | IMM      |          |           |   |   |  |  |  |  |  |      |
| SUBS             | SUB.L.ERs.ERd          | L    | 1                  | A        | 1:ers    | 0:erd    |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | SUBS.#1.ERd            | L    | 1                  | B        | 0        | 0:erd    |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | SUBS.#2.ERd            | L    | 1                  | B        | 8        | 0:erd    |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | SUBS.#4.ERd            | L    | 1                  | B        | 9        | 0:erd    |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
| SUBX             | SUBX.#xx:8.Rd          | B    | B                  | rd       | IMM      |          |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
|                  | SUBX.Rs.Rd             | B    | 1                  | E        | rs       | rd       |          |          |          |          |          |           |   |   |  |  |  |  |  |      |
| TAS              | TAS.@ERd <sup>3</sup>  | B    | 0                  | 1        | E        | 0        | 7        | B        | 0:erd    | C        |          |           |   |   |  |  |  |  |  |      |
| TRAPA            | TRAPA.#x:2             | —    | 5                  | 7        | 00:IMM   | 0        |          |          |          |          |          |           |   |   |  |  |  |  |  |      |



| Instruction | Mnemonic         | Size | Instruction Format |          |          |          |          |          |          |          |          |           |  |  |  |  |  |
|-------------|------------------|------|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|--|--|--|--|--|
|             |                  |      | 1st byte           | 2nd byte | 3rd byte | 4th byte | 5th byte | 6th byte | 7th byte | 8th byte | 9th byte | 10th byte |  |  |  |  |  |
| XOR         | XOR.B #xx:8,Rd   | B    | D                  | rd       | IMM      |          |          |          |          |          |          |           |  |  |  |  |  |
|             | XOR.B Rs,Rd      | B    | 1                  | 5        | rs       | rd       |          |          |          |          |          |           |  |  |  |  |  |
|             | XOR.W #xx:16,Rd  | W    | 7                  | 9        | 5        | rd       | IMM      |          |          |          |          |           |  |  |  |  |  |
|             | XOR.W Rs,Rd      | W    | 6                  | 5        | rs       | rd       |          |          |          |          |          |           |  |  |  |  |  |
|             | XOR.L #xx:32,ERd | L    | 7                  | A        | 5        | 0:erd    | IMM      |          |          |          |          |           |  |  |  |  |  |
|             | XOR.L ERs,ERd    | L    | 0                  | 1        | F        | 0        | 6        | 5        | 0:ers    | 0:erd    |          |           |  |  |  |  |  |
| XORC        | XORC #xx:8,CCR   | B    | 0                  | 5        | IMM      |          |          |          |          |          |          |           |  |  |  |  |  |
|             | XORC #xx:8,EXR   | B    | 0                  | 1        | 4        | 1        | 0        | 5        | IMM      |          |          |           |  |  |  |  |  |

- Notes: 1. These instructions are supported by the H8S/z600 CPU only.  
2. Bit 7 of the 4th byte of the MOV.L ERs, @(d:32,ERd) instruction can be either 1 or 0.  
3. Only register ER0, ER1, ER4, or ER5 should be used when using the TAS instruction.

Legend:

IMM:

abs: Immediate data (2, 3, 8, 16, or 32 bits)

disp: Absolute address (8, 16, 24, or 32 bits)

rs, rd, rn: Displacement (8, 16, or 32 bits)

Register field (4 bits specifying an 8-bit or 16-bit register. The symbols rs, rd, and rn correspond to operand symbols Rs, Rd, and Rn.)

ers, erd, ern, erm: Register field (3 bits specifying an address register or 32-bit register. The symbols ers, erd, ern, and erm correspond to operand symbols ERs, ERd, ERn, and ERm.)

The register fields specify general registers as follows.

| Address Register |                  | 16-Bit Register |                  | 8-Bit Register |                  |
|------------------|------------------|-----------------|------------------|----------------|------------------|
| Register Field   | General Register | Register Field  | General Register | Register Field | General Register |
| 000              | ER0              | 0000            | R0               | 0000           | R0H              |
| 001              | ER1              | 0001            | R1               | 0001           | R1H              |
| ...              | ...              | ...             | ...              | ...            | ...              |
| ...              | ...              | ...             | ...              | ...            | ...              |
| 111              | ER7              | 0111            | R7               | 0111           | R7H              |
|                  |                  | 1000            | E0               | 1000           | R0L              |
|                  |                  | 1001            | E1               | 1001           | R1L              |
|                  |                  | ...             | ...              | ...            | ...              |
|                  |                  | 1111            | E7               | 1111           | R7L              |

## 2.5 Operation Code Map

Table 2.3 shows an operation code map.

**Table 2.3 Operation Code Map (1)**

**Operation Code:**

|          |    |          |    |
|----------|----|----------|----|
| 1st byte |    | 2nd byte |    |
| AH       | AL | BH       | BL |

| AH | AL            | 0             | 1             | 2             | 3              | 4               | 5               | 6              | 7               | 8              | 9                | A                | B               | C               | D              | E               | F              |
|----|---------------|---------------|---------------|---------------|----------------|-----------------|-----------------|----------------|-----------------|----------------|------------------|------------------|-----------------|-----------------|----------------|-----------------|----------------|
| 0  | NOP           | Table 2.3 (2) | STC           | Table 2.3 (2) | LDC            | ORC             | XORC            | ANDC           | LDC             | ADD            | ADD              | Table 2.3 (2)    | Table 2.3 (2)   | MOV             | ADDX           | Table 2.3 (2)   | Table 2.3 (2)  |
| 1  | Table 2.3 (2) | Table 2.3 (2) | Table 2.3 (2) | Table 2.3 (2) | Table 2.3 (2)  | OR              | XOR             | AND            | Table 2.3 (2)   | SUB            | SUB              | Table 2.3 (2)    | Table 2.3 (2)   | CMP             | SUBX           | Table 2.3 (2)   | Table 2.3 (2)  |
| 2  |               | MOV,B         |               |               |                |                 |                 |                |                 |                |                  |                  |                 |                 |                |                 |                |
| 3  |               | MOV,B         |               |               |                |                 |                 |                |                 |                |                  |                  |                 |                 |                |                 |                |
| 4  | BRA           | BRN           | BHI           | BLS           | BCC            | BCS             | BNE             | BEQ            | BVC             | BVS            | BPL              | BMI              | BGE             | BLT             | BGT            | BLE             |                |
| 5  | MULXU         | DIVXU         | MULXU         | DIVXU         | RTS            | BSR             | RTE             | TRAPA          | Table 2.3 (2)   | JMP            | JMP              |                  | BSR             | JSR             |                |                 |                |
| 6  | BSET          | BNOT          | BCLR          | BTST          | OR             | XOR             | AND             | BST            | BIST            | MOV            | MOV              | Table 2.3 (2)    | Table 2.3 (2)   | MOV             |                |                 |                |
| 7  |               |               |               |               | <del>BCR</del> | <del>BXOR</del> | <del>BAND</del> | <del>BLD</del> | <del>BILD</del> | <del>BOR</del> | <del>BIXOR</del> | <del>BIAND</del> | <del>BIOR</del> | <del>BAND</del> | <del>BOR</del> | <del>BAND</del> | <del>BOR</del> |
| 8  |               | ADD           |               |               |                |                 |                 |                |                 |                |                  |                  |                 |                 |                |                 |                |
| 9  |               | ADDX          |               |               |                |                 |                 |                |                 |                |                  |                  |                 |                 |                |                 |                |
| A  |               | CMP           |               |               |                |                 |                 |                |                 |                |                  |                  |                 |                 |                |                 |                |
| B  |               | SUBX          |               |               |                |                 |                 |                |                 |                |                  |                  |                 |                 |                |                 |                |
| C  |               | OR            |               |               |                |                 |                 |                |                 |                |                  |                  |                 |                 |                |                 |                |
| D  |               | XOR           |               |               |                |                 |                 |                |                 |                |                  |                  |                 |                 |                |                 |                |
| E  |               | AND           |               |               |                |                 |                 |                |                 |                |                  |                  |                 |                 |                |                 |                |
| F  |               | MOV           |               |               |                |                 |                 |                |                 |                |                  |                  |                 |                 |                |                 |                |

Note: \* These instructions are supported by the H8S/2600 CPU only.

Table 2.3 Operation Code Map (2)

|          |    |          |    |
|----------|----|----------|----|
| 1st byte |    | 2nd byte |    |
| AH       | AL | BH       | BL |

Operation Code:

| BH | 0     | 1             | 2   | 3             | 4       | 5    | 6    | 7     | 8     | 9   | A       | B   | C    | D    | E   | F    |
|----|-------|---------------|-----|---------------|---------|------|------|-------|-------|-----|---------|-----|------|------|-----|------|
| AH | MOV   | LDM           | STM | LDC           | STC     |      | MAC* |       | SLEEP |     | CLRMAC* |     |      |      | TAS |      |
| 0A | INC   |               |     |               |         |      |      |       |       |     |         |     | ADD  |      |     |      |
| 0B | ADDS  |               |     |               |         | INC  |      | INC   | ADDS  |     |         |     |      | INC  |     | INC  |
| 0F | DAA   |               |     |               |         |      |      |       |       |     |         |     | MOV  |      |     |      |
| 10 | SHLL  |               |     | SHLL          |         |      |      | SHLL  | SHAL  |     |         |     | SHAL |      |     | SHAL |
| 11 | SHLR  |               |     | SHLR          |         |      |      | SHLR  | SHAR  |     |         |     | SHAR |      |     | SHAR |
| 12 | ROTXL |               |     | ROTXL         |         |      |      | ROTXL | ROTL  |     |         |     | ROTL |      |     | ROTL |
| 13 | ROTXR |               |     | ROTXR         |         |      |      | ROTXR | ROTR  |     |         |     | ROTR |      |     | ROTR |
| 17 | NOT   |               |     | NOT           |         | EXTU |      | EXTU  | NEG   |     |         | NEG |      | EXTS |     | EXTS |
| 1A | DEC   |               |     |               |         |      |      |       |       |     |         |     |      |      |     |      |
| 1B | SUBS  |               |     |               |         | DEC  |      | DEC   | SUBS  |     |         |     |      | DEC  |     | DEC  |
| 1F | DAS   |               |     |               |         |      |      |       |       |     |         |     |      |      |     |      |
| 58 | BRA   | BRN           | BHI | BLS           | BCC     | BCS  | BNE  | BEQ   | BVC   | BVS | BPL     | BMI | BGE  | BLT  | BGT | BLE  |
| 6A | MOV   | Table 2.3 (4) | MOV | Table 2.3 (4) | MOV/FPE |      |      |       | MOV   |     | MOV     |     |      |      |     |      |
| 79 | MOV   | ADD           | CMP | SUB           | OR      | XOR  | AND  |       |       |     |         |     |      |      |     |      |
| 7A | MOV   | ADD           | CMP | SUB           | OR      | XOR  | AND  |       |       |     |         |     |      |      |     |      |

Note: \* These instructions are supported by the H8S/2600 CPU only.

Table 2.3 Operation Code Map (3)



| 1st byte |    | 2nd byte |    | 3rd byte |    | 4th byte |    |
|----------|----|----------|----|----------|----|----------|----|
| AH       | AL | BH       | BL | CH       | CL | DH       | DL |

| CL       | 0     | 1    | 2     | 3     | 4    | 5     | 6     | 7   | 8   | 9 | A | B | C | D | E | F |
|----------|-------|------|-------|-------|------|-------|-------|-----|-----|---|---|---|---|---|---|---|
| AHALBHCL | MULXS |      | MULXS |       |      |       |       |     |     |   |   |   |   |   |   |   |
| 01C05    | MULXS |      |       |       |      |       |       |     |     |   |   |   |   |   |   |   |
| 01D05    | DIVXS |      |       | DIVXS |      |       |       |     |     |   |   |   |   |   |   |   |
| 01F06    |       |      |       |       | OR   | XOR   | AND   |     |     |   |   |   |   |   |   |   |
| 7C06*1   |       |      |       | BTST  |      |       |       |     |     |   |   |   |   |   |   |   |
| 7C07*1   |       |      |       | BTST  | BOR  | BXOR  | BAND  | BLD | BLD |   |   |   |   |   |   |   |
| 7D06*1   | BSET  | BNOT | BCLR  |       | BIOR | BIXOR | BIAND | BST | BST |   |   |   |   |   |   |   |
| 7D07*1   | BSET  | BNOT | BCLR  |       |      |       |       |     |     |   |   |   |   |   |   |   |
| 7Eaa6*2  |       |      |       | BTST  |      |       |       |     |     |   |   |   |   |   |   |   |
| 7Eaa7*2  |       |      |       | BTST  | BOR  | BXOR  | BAND  | BLD | BLD |   |   |   |   |   |   |   |
| 7Faad*2  | BSET  | BNOT | BCLR  |       | BIOR | BIXOR | BIAND | BST | BST |   |   |   |   |   |   |   |
| 7Faaf*2  | BSET  | BNOT | BCLR  |       |      |       |       |     |     |   |   |   |   |   |   |   |

Notes: 1. The letter "r" indicates a register field.  
 2. The letters "aa" indicate an absolute address field.



**Table 2.3 Operation Code Map (4)**

| Operation Code:   |  | 1st byte |      | 2nd byte |      | 3rd byte |      | 4th byte |      | 5th byte |     | 6th byte |       |     |     |   |   |
|-------------------|--|----------|------|----------|------|----------|------|----------|------|----------|-----|----------|-------|-----|-----|---|---|
|                   |  | AH       | AL   | BH       | BL   | CH       | CL   | DH       | DL   | EH       | EL  | FH       | FL    |     |     |   |   |
| EL                | Instruction when most significant bit of FH is 0.<br>Instruction when most significant bit of FH is 1. | 0        | 1    | 2        | 3    | 4        | 5    | 6        | 7    | 8        | 9   | A        | B     | C   | D   | E | F |
| AHALBHELCHLDHLEFN |  |          |      |          |      |          |      |          |      |          |     |          |       |     |     |   |   |
| 6A10aaaa6*        |  |          |      |          | BTST |          |      |          |      |          |     |          |       |     |     |   |   |
| 6A10aaaa7*        |  |          |      |          |      | BOR      | BIOR | BXOR     | BAND | BLD      | BLD | BIAND    | BIAND | BLD | BLD |   |   |
| 6A18aaaa6*        |  |          |      |          |      |          |      |          |      | BST      | BST | BIST     | BIST  |     |     |   |   |
| 6A18aaaa7*        |  |          |      |          |      |          |      |          |      |          |     |          |       |     |     |   |   |
|                   |  | BSET     | BNOT | BCLR     |      |          |      |          |      |          |     |          |       |     |     |   |   |

| Operation Code:   |  | 1st byte |      | 2nd byte |    | 3rd byte |    | 4th byte |    | 5th byte |    | 6th byte |    | 7th byte |    | 8th byte |    |
|-------------------|--|----------|------|----------|----|----------|----|----------|----|----------|----|----------|----|----------|----|----------|----|
|                   |  | AH       | AL   | BH       | BL | CH       | CL | DH       | DL | EH       | EL | FH       | FL | GH       | GL | HH       | HL |
| EL                | Instruction when most significant bit of HH is 0.<br>Instruction when most significant bit of HH is 1. | 0        | 1    | 2        | 3  | 4        | 5  | 6        | 7  | 8        | 9  | A        | B  | C        | D  | E        | F  |
| AHALBHEL...FHFLGH |  |          |      |          |    |          |    |          |    |          |    |          |    |          |    |          |    |
| 6A30aaaaaaa6*     |  |          |      |          |    |          |    |          |    |          |    |          |    |          |    |          |    |
| 6A30aaaaaaa7*     |  |          |      |          |    |          |    |          |    |          |    |          |    |          |    |          |    |
| 6A38aaaaaaa6*     |  |          |      |          |    |          |    |          |    |          |    |          |    |          |    |          |    |
| 6A38aaaaaaa7*     |  |          |      |          |    |          |    |          |    |          |    |          |    |          |    |          |    |
|                   |  | BSET     | BNOT | BCLR     |    |          |    |          |    |          |    |          |    |          |    |          |    |

Note: \* The letters "aa" indicate an absolute address field.

## 2.6 Number of States Required for Instruction Execution

The tables in this section can be used to calculate the number of states required for instruction execution by the CPU. Table 2.5 indicates the number of instruction fetch, data read/write, and other cycles occurring in each instruction. Table 2.4 indicates the number of states required for each cycle, depending on its size. The number of states required for each cycle depends on the product. See the hardware manual named for the relevant product for details. The number of states required for execution of an instruction can be calculated from these two tables as follows:

$$\text{Execution states} = I \times S_I + J \times S_J + K \times S_K + L \times S_L + M \times S_M + N \times S_N$$

**Examples:** Advanced mode, program code and stack located in external memory, on-chip supporting modules accessed in two states with 8-bit bus width, external devices accessed in three states with one wait state and 16-bit bus width.

### 1. BSET #0, @FFFFC7:8

From table 2.5:

$$I = L = 2, \quad J = K = M = N = 0$$

From table 2.4:

$$S_I = 4, \quad S_L = 2$$

$$\text{Number of states required for execution} = 2 \times 4 + 2 \times 2 = 12$$

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From table 2.5:

$$I = J = K = 2, \quad L = M = N = 0$$

From table 2.4:

$$S_I = S_J = S_K = 4$$

$$\text{Number of states required for execution} = 2 \times 4 + 2 \times 4 + 2 \times 4 = 24$$

**Table 2.4** Number of States per Cycle

|                     |                |           | Access Conditions         |                |                 |                |                |        |
|---------------------|----------------|-----------|---------------------------|----------------|-----------------|----------------|----------------|--------|
|                     |                |           | On-Chip Supporting Module |                | External Device |                |                |        |
|                     |                |           |                           |                | 8-Bit Bus       |                | 16-Bit Bus     |        |
| Cycle               | On-Chip Memory | 8-Bit Bus | 16-Bit Bus                | 2-State Access | 3-State Access  | 2-State Access | 3-State Access |        |
| Instruction fetch   | $S_i$          | 1         | 2n                        | n              | 4               | 6 + 2m         | 2              | 3 + m* |
| Branch address read | $S_j$          |           |                           |                |                 |                |                |        |
| Stack operation     | $S_k$          |           |                           |                |                 |                |                |        |
| Byte data access    | $S_L$          |           | n                         |                | 2               | 3 + m          |                |        |
| Word data access    | $S_M$          |           | 2n                        |                | 4               | 6 + 2m         |                |        |
| Internal operation  | $S_N$          | 1         | 1                         | 1              | 1               | 1              | 1              | 1      |

Note: \* For the MOVFPE and MOVTPPE instructions, refer to the relevant microcontroller hardware manual.

Legend:

m: Number of wait states inserted into external device access

n: Number of states required for access to an on-chip supporting module. For the specific number, refer to the relevant microcontroller hardware manual.

Table 2.5 Number of Cycles in Instruction Execution

| Instruction | Mnemonic          | Branch            |              |                 |                  |                  |                    |
|-------------|-------------------|-------------------|--------------|-----------------|------------------|------------------|--------------------|
|             |                   | Instruction Fetch | Address Read | Stack Operation | Byte Data Access | Word Data Access | Internal Operation |
|             |                   | I                 | J            | K               | L                | M                | N                  |
| ADD         | ADD.B #xx:8,Rd    | 1                 |              |                 |                  |                  |                    |
|             | ADD.B Rs,Rd       | 1                 |              |                 |                  |                  |                    |
|             | ADD.W #xx:16,Rd   | 2                 |              |                 |                  |                  |                    |
|             | ADD.W Rs,Rd       | 1                 |              |                 |                  |                  |                    |
|             | ADD.L #xx:32,ERd  | 3                 |              |                 |                  |                  |                    |
|             | ADD.L ERs,ERd     | 1                 |              |                 |                  |                  |                    |
| ADDS        | ADDS #1/2/4,ERd   | 1                 |              |                 |                  |                  |                    |
| ADDX        | ADDX #xx:8,Rd     | 1                 |              |                 |                  |                  |                    |
|             | ADDX Rs,Rd        | 1                 |              |                 |                  |                  |                    |
| AND         | AND.B #xx:8,Rd    | 1                 |              |                 |                  |                  |                    |
|             | AND.B Rs,Rd       | 1                 |              |                 |                  |                  |                    |
|             | AND.W #xx:16,Rd   | 2                 |              |                 |                  |                  |                    |
|             | AND.L #xx:32,ERd  | 3                 |              |                 |                  |                  |                    |
|             | AND.L ERs,ERd     | 2                 |              |                 |                  |                  |                    |
| ANDC        | ANDC #xx:8,CCR    | 1                 |              |                 |                  |                  |                    |
|             | ANDC #xx:8,EXR    | 2                 |              |                 |                  |                  |                    |
| BAND        | BAND #xx:3,Rd     | 1                 |              |                 |                  |                  |                    |
|             | BAND #xx:3,@ERd   | 2                 |              |                 | 1                |                  |                    |
|             | BAND #xx:3,@aa:8  | 2                 |              |                 | 1                |                  |                    |
|             | BAND #xx:3,@aa:16 | 3                 |              |                 | 1                |                  |                    |
|             | BAND #xx:3,@aa:32 | 4                 |              |                 | 1                |                  |                    |
| Bcc         | BRA d:8 (BT d:8)  | 2                 |              |                 |                  |                  |                    |
|             | BRN d:8 (BF d:8)  | 2                 |              |                 |                  |                  |                    |
|             | BHI d:8           | 2                 |              |                 |                  |                  |                    |
|             | BLS d:8           | 2                 |              |                 |                  |                  |                    |
|             | BCC d:8 (BHS d:8) | 2                 |              |                 |                  |                  |                    |
|             | BCS d:8 (BLO d:8) | 2                 |              |                 |                  |                  |                    |
|             | BNE d:8           | 2                 |              |                 |                  |                  |                    |
|             | BEQ d:8           | 2                 |              |                 |                  |                  |                    |
|             | BVC d:8           | 2                 |              |                 |                  |                  |                    |
|             | BVS d:8           | 2                 |              |                 |                  |                  |                    |
|             | BPL d:8           | 2                 |              |                 |                  |                  |                    |
|             | BMI d:8           | 2                 |              |                 |                  |                  |                    |
|             | BGE d:8           | 2                 |              |                 |                  |                  |                    |
|             | BLT d:8           | 2                 |              |                 |                  |                  |                    |
|             | BGT d:8           | 2                 |              |                 |                  |                  |                    |



| Instruction    | Mnemonic            | Instruction<br>Fetch | Branch          | Stack<br>Operation | Byte Data<br>Access | Word Data<br>Access | Internal<br>Operation |
|----------------|---------------------|----------------------|-----------------|--------------------|---------------------|---------------------|-----------------------|
|                |                     |                      | Address<br>Read |                    |                     |                     |                       |
|                |                     | I                    | J               | K                  | L                   | M                   | N                     |
| Bcc            | BLE d:8             | 2                    |                 |                    |                     |                     |                       |
|                | BRA d:16 (BT d:16)  | 2                    |                 |                    |                     |                     | 1                     |
|                | BRN d:16 (BF d:16)  | 2                    |                 |                    |                     |                     | 1                     |
|                | BHI d:16            | 2                    |                 |                    |                     |                     | 1                     |
|                | BLS d:16            | 2                    |                 |                    |                     |                     | 1                     |
|                | BCC d:16 (BHS d:16) | 2                    |                 |                    |                     |                     | 1                     |
|                | BCS d:16 (BLO d:16) | 2                    |                 |                    |                     |                     | 1                     |
|                | BNE d:16            | 2                    |                 |                    |                     |                     | 1                     |
|                | BEQ d:16            | 2                    |                 |                    |                     |                     | 1                     |
|                | BVC d:16            | 2                    |                 |                    |                     |                     | 1                     |
|                | BVS d:16            | 2                    |                 |                    |                     |                     | 1                     |
|                | BPL d:16            | 2                    |                 |                    |                     |                     | 1                     |
|                | BMI d:16            | 2                    |                 |                    |                     |                     | 1                     |
|                | BGE d:16            | 2                    |                 |                    |                     |                     | 1                     |
|                | BLT d:16            | 2                    |                 |                    |                     |                     | 1                     |
|                | BGT d:16            | 2                    |                 |                    |                     |                     | 1                     |
| BLE d:16       | 2                   |                      |                 |                    |                     | 1                   |                       |
| BCLR           | BCLR #xx:3,Rd       | 1                    |                 |                    |                     |                     |                       |
|                | BCLR #xx:3,@ERd     | 2                    |                 |                    | 2                   |                     |                       |
|                | BCLR #xx:3,@aa:8    | 2                    |                 |                    | 2                   |                     |                       |
|                | BCLR #xx:3,@aa:16   | 3                    |                 |                    | 2                   |                     |                       |
|                | BCLR #xx:3,@aa:32   | 4                    |                 |                    | 2                   |                     |                       |
|                | BCLR Rn,Rd          | 1                    |                 |                    |                     |                     |                       |
|                | BCLR Rn,@ERd        | 2                    |                 |                    | 2                   |                     |                       |
|                | BCLR Rn,@aa:8       | 2                    |                 |                    | 2                   |                     |                       |
|                | BCLR Rn,@aa:16      | 3                    |                 |                    | 2                   |                     |                       |
| BCLR Rn,@aa:32 | 4                   |                      |                 | 2                  |                     |                     |                       |
| BIAND          | BIAND #xx:3,Rd      | 1                    |                 |                    |                     |                     |                       |
|                | BIAND #xx:3,@ERd    | 2                    |                 |                    | 1                   |                     |                       |
|                | BIAND #xx:3,@aa:8   | 2                    |                 |                    | 1                   |                     |                       |
|                | BIAND #xx:3,@aa:16  | 3                    |                 |                    | 1                   |                     |                       |
|                | BIAND #xx:3,@aa:32  | 4                    |                 |                    | 1                   |                     |                       |
| BILD           | BILD #xx:3,Rd       | 1                    |                 |                    |                     |                     |                       |
|                | BILD #xx:3,@ERd     | 2                    |                 |                    | 1                   |                     |                       |
|                | BILD #xx:3,@aa:8    | 2                    |                 |                    | 1                   |                     |                       |
|                | BILD #xx:3,@aa:16   | 3                    |                 |                    | 1                   |                     |                       |
|                | BILD #xx:3,@aa:32   | 4                    |                 |                    | 1                   |                     |                       |

| Instruction | Mnemonic           | Instruction | Branch  | Stack | Byte Data | Word Data | Internal |
|-------------|--------------------|-------------|---------|-------|-----------|-----------|----------|
|             |                    | Fetch       | Address |       |           |           |          |
|             |                    | I           | J       | K     | L         | M         | N        |
| BIOR        | BIOR #xx:8,Rd      | 1           |         |       |           |           |          |
|             | BIOR #xx:8,@ERd    | 2           |         |       | 1         |           |          |
|             | BIOR #xx:8,@aa:8   | 2           |         |       | 1         |           |          |
|             | BIOR #xx:8,@aa:16  | 3           |         |       | 1         |           |          |
|             | BIOR #xx:8,@aa:32  | 4           |         |       | 1         |           |          |
| BIST        | BIST #xx:3,Rd      | 1           |         |       |           |           |          |
|             | BIST #xx:3,@ERd    | 2           |         |       | 2         |           |          |
|             | BIST #xx:3,@aa:8   | 2           |         |       | 2         |           |          |
|             | BIST #xx:3,@aa:16  | 3           |         |       | 2         |           |          |
|             | BIST #xx:3,@aa:32  | 4           |         |       | 2         |           |          |
| BIXOR       | BIXOR #xx:3,Rd     | 1           |         |       |           |           |          |
|             | BIXOR #xx:3,@ERd   | 2           |         |       | 1         |           |          |
|             | BIXOR #xx:3,@aa:8  | 2           |         |       | 1         |           |          |
|             | BIXOR #xx:3,@aa:16 | 3           |         |       | 1         |           |          |
|             | BIXOR #xx:3,@aa:32 | 4           |         |       | 1         |           |          |
| BLD         | BLD #xx:3,Rd       | 1           |         |       |           |           |          |
|             | BLD #xx:3,@ERd     | 2           |         |       | 1         |           |          |
|             | BLD #xx:3,@aa:8    | 2           |         |       | 1         |           |          |
|             | BLD #xx:3,@aa:16   | 3           |         |       | 1         |           |          |
|             | BLD #xx:3,@aa:32   | 4           |         |       | 1         |           |          |
| BNOT        | BNOT #xx:3,Rd      | 1           |         |       |           |           |          |
|             | BNOT #xx:3,@ERd    | 2           |         |       | 2         |           |          |
|             | BNOT #xx:3,@aa:8   | 2           |         |       | 2         |           |          |
|             | BNOT #xx:3,@aa:16  | 3           |         |       | 2         |           |          |
|             | BNOT #xx:3,@aa:32  | 4           |         |       | 2         |           |          |
|             | BNOT Rn,Rd         | 1           |         |       |           |           |          |
|             | BNOT Rn,@ERd       | 2           |         |       | 2         |           |          |
|             | BNOT Rn,@aa:8      | 2           |         |       | 2         |           |          |
|             | BNOT Rn,@aa:16     | 3           |         |       | 2         |           |          |
|             | BNOT Rn,@aa:32     | 4           |         |       | 2         |           |          |
| BOR         | BOR #xx:3,Rd       | 1           |         |       |           |           |          |
|             | BOR #xx:3,@ERd     | 2           |         |       | 1         |           |          |
|             | BOR #xx:3,@aa:8    | 2           |         |       | 1         |           |          |
|             | BOR #xx:3,@aa:16   | 3           |         |       | 1         |           |          |
|             | BOR #xx:3,@aa:32   | 4           |         |       | 1         |           |          |
| BSET        | BSET #xx:3,Rd      | 1           |         |       |           |           |          |
|             | BSET #xx:3,@ERd    | 2           |         |       | 2         |           |          |
|             | BSET #xx:3,@aa:8   | 2           |         |       | 2         |           |          |

| Instruction          | Mnemonic          |          | Instruction | Branch  | Stack | Byte Data | Word Data | Internal           |
|----------------------|-------------------|----------|-------------|---------|-------|-----------|-----------|--------------------|
|                      |                   |          | Fetch       | Address |       |           |           |                    |
|                      |                   |          | I           | J       | K     | L         | M         | N                  |
| BSET                 | BSET #xx:3,@aa:16 |          | 3           |         |       | 2         |           |                    |
|                      | BSET #xx:3,@aa:32 |          | 4           |         |       | 2         |           |                    |
|                      | BSET Rn,Rd        |          | 1           |         |       |           |           |                    |
|                      | BSET Rn,@ERd      |          | 2           |         |       | 2         |           |                    |
|                      | BSET Rn,@aa:8     |          | 2           |         |       | 2         |           |                    |
|                      | BSET Rn,@aa:16    |          | 3           |         |       | 2         |           |                    |
|                      | BSET Rn,@aa:32    |          | 4           |         |       | 2         |           |                    |
| BSR                  | BSR d:8           | Normal   | 2           |         | 1     |           |           |                    |
|                      |                   | Advanced | 2           |         | 2     |           |           |                    |
|                      | BSR d:16          | Normal   | 2           |         | 1     |           |           | 1                  |
|                      |                   | Advanced | 2           |         | 2     |           |           | 1                  |
| BST                  | BST #xx:3,Rd      |          | 1           |         |       |           |           |                    |
|                      | BST #xx:3,@ERd    |          | 2           |         |       | 2         |           |                    |
|                      | BST #xx:3,@aa:8   |          | 2           |         |       | 2         |           |                    |
|                      | BST #xx:3,@aa:16  |          | 3           |         |       | 2         |           |                    |
|                      | BST #xx:3,@aa:32  |          | 4           |         |       | 2         |           |                    |
| BTST                 | BTST #xx:3,Rd     |          | 1           |         |       |           |           |                    |
|                      | BTST #xx:3,@ERd   |          | 2           |         |       | 1         |           |                    |
|                      | BTST #xx:3,@aa:8  |          | 2           |         |       | 1         |           |                    |
|                      | BTST #xx:3,@aa:16 |          | 3           |         |       | 1         |           |                    |
|                      | BTST #xx:3,@aa:32 |          | 4           |         |       | 1         |           |                    |
|                      | BTST Rn,Rd        |          | 1           |         |       |           |           |                    |
|                      | BTST Rn,@ERd      |          | 2           |         |       | 1         |           |                    |
|                      | BTST Rn,@aa:8     |          | 2           |         |       | 1         |           |                    |
|                      | BTST Rn,@aa:16    |          | 3           |         |       | 1         |           |                    |
| BTST Rn,@aa:32       |                   | 4        |             |         | 1     |           |           |                    |
| BXOR                 | BXOR #xx:3,Rd     |          | 1           |         |       |           |           |                    |
|                      | BXOR #xx:3,@ERd   |          | 2           |         |       | 1         |           |                    |
|                      | BXOR #xx:3,@aa:8  |          | 2           |         |       | 1         |           |                    |
|                      | BXOR #xx:3,@aa:16 |          | 3           |         |       | 1         |           |                    |
|                      | BXOR #xx:3,@aa:32 |          | 4           |         |       | 1         |           |                    |
| CLRMAC <sup>*5</sup> | CLRMAC            |          | 1           |         |       |           |           | 1 <sup>*3 *6</sup> |
| CMP                  | CMP.B #xx:8,Rd    |          | 1           |         |       |           |           |                    |
|                      | CMP.B Rs,Rd       |          | 1           |         |       |           |           |                    |
|                      | CMP.W #xx:16,Rd   |          | 2           |         |       |           |           |                    |
|                      | CMP.W Rs,Rd       |          | 1           |         |       |           |           |                    |
|                      | CMP.L #xx:32,ERd  |          | 3           |         |       |           |           |                    |
|                      | CMP.L ERs,ERd     |          | 1           |         |       |           |           |                    |

| Instruction | Mnemonic            |          | Instruction | Branch  | Stack | Byte Data     | Word Data | Internal |
|-------------|---------------------|----------|-------------|---------|-------|---------------|-----------|----------|
|             |                     |          | Fetch       | Address |       |               |           |          |
|             |                     |          | I           | J       | K     | L             | M         | N        |
| DAA         | DAA Rd              |          | 1           |         |       |               |           |          |
| DAS         | DAS Rd              |          | 1           |         |       |               |           |          |
| DEC         | DEC.B Rd            |          | 1           |         |       |               |           |          |
|             | DEC.W #1/2,Rd       |          | 1           |         |       |               |           |          |
|             | DEC.L #1/2,ERd      |          | 1           |         |       |               |           |          |
| DIVXS       | DIVXS.B Rs,Rd       |          | 2           |         |       |               |           | 11       |
|             | DIVXS.W Rs,ERd      |          | 2           |         |       |               |           | 19       |
| DIVXU       | DIVXU.B Rs,Rd       |          | 1           |         |       |               |           | 11       |
|             | DIVXU.W Rs,ERd      |          | 1           |         |       |               |           | 19       |
| EEPMOV      | EEPMOV.B            |          | 2           |         |       | $2n + 2^{*1}$ |           |          |
|             | EEPMOV.W            |          | 2           |         |       | $2n + 2^{*1}$ |           |          |
| EXTS        | EXTS.W Rd           |          | 1           |         |       |               |           |          |
|             | EXTS.L ERd          |          | 1           |         |       |               |           |          |
| EXTU        | EXTU.W Rd           |          | 1           |         |       |               |           |          |
|             | EXTU.L ERd          |          | 1           |         |       |               |           |          |
| INC         | INC.B Rd            |          | 1           |         |       |               |           |          |
|             | INC.W #1/2,Rd       |          | 1           |         |       |               |           |          |
|             | INC.L #1/2,ERd      |          | 1           |         |       |               |           |          |
| JMP         | JMP @ERn            |          | 2           |         |       |               |           |          |
|             | JMP @aa:24          |          | 2           |         |       |               |           | 1        |
|             | JMP @ @aa:8         | Normal   | 2           | 1       |       |               |           | 1        |
|             |                     | Advanced | 2           | 2       |       |               |           | 1        |
| JSR         | JSR @ERn            | Normal   | 2           |         | 1     |               |           |          |
|             |                     | Advanced | 2           |         | 2     |               |           |          |
|             | JSR @aa:24          | Normal   | 2           |         | 1     |               |           | 1        |
|             |                     | Advanced | 2           |         | 2     |               |           | 1        |
|             | JSR @ @aa:8         | Normal   | 2           | 1       | 1     |               |           |          |
|             |                     | Advanced | 2           | 2       | 2     |               |           |          |
| LDC         | LDC #xx:8,CCR       |          | 1           |         |       |               |           |          |
|             | LDC #xx:8,EXR       |          | 2           |         |       |               |           |          |
|             | LDC Rs,CCR          |          | 1           |         |       |               |           |          |
|             | LDC Rs,EXR          |          | 1           |         |       |               |           |          |
|             | LDC @ERs,CCR        |          | 2           |         |       |               | 1         |          |
|             | LDC @ERs,EXR        |          | 2           |         |       |               | 1         |          |
|             | LDC @(d:16,ERs),CCR |          | 3           |         |       |               | 1         |          |
|             | LDC @(d:16,ERs),EXR |          | 3           |         |       |               | 1         |          |
|             | LDC @(d:32,ERs),CCR |          | 5           |         |       |               | 1         |          |
|             | LDC @(d:32,ERs),EXR |          | 5           |         |       |               | 1         |          |

| Instruction         | Mnemonic               | Instruction Fetch | Branch       |                 |                  |                  |                    |   |
|---------------------|------------------------|-------------------|--------------|-----------------|------------------|------------------|--------------------|---|
|                     |                        |                   | Address Read | Stack Operation | Byte Data Access | Word Data Access | Internal Operation |   |
|                     |                        | I                 | J            | K               | L                | M                | N                  |   |
| LDC                 | LDC @ERs+,CCR          | 2                 |              |                 |                  | 1                | 1                  |   |
|                     | LDC @ERs+,EXR          | 2                 |              |                 |                  | 1                | 1                  |   |
|                     | LDC @aa:16,CCR         | 3                 |              |                 |                  | 1                |                    |   |
|                     | LDC @aa:16,EXR         | 3                 |              |                 |                  | 1                |                    |   |
|                     | LDC @aa:32,CCR         | 4                 |              |                 |                  | 1                |                    |   |
|                     | LDC @aa:32,EXR         | 4                 |              |                 |                  | 1                |                    |   |
| LDM                 | LDM.L @SP+,(ERn-ERn+1) | 2                 |              | 4               |                  |                  | 1                  |   |
|                     | LDM.L @SP+,(ERn-ERn+2) | 2                 |              | 6               |                  |                  | 1                  |   |
|                     | LDM.L @SP+,(ERn-ERn+3) | 2                 |              | 8               |                  |                  | 1                  |   |
| LDMAC <sup>*5</sup> | LDMAC ERs,MACH         | 1                 |              |                 |                  |                  | 1*3**6             |   |
|                     | LDMAC ERs,MACL         | 1                 |              |                 |                  |                  | 1*3**6             |   |
| MAC <sup>*5</sup>   | MAC @ERn+,@ERm+        | 2                 |              |                 |                  | 2                |                    |   |
| MOV                 | MOV.B #xx:8,Rd         | 1                 |              |                 |                  |                  |                    |   |
|                     | MOV.B Rs,Rd            | 1                 |              |                 |                  |                  |                    |   |
|                     | MOV.B @ERs,Rd          | 1                 |              |                 | 1                |                  |                    |   |
|                     | MOV.B @(d:16,ERs),Rd   | 2                 |              |                 | 1                |                  |                    |   |
|                     | MOV.B @(d:32,ERs),Rd   | 4                 |              |                 | 1                |                  |                    |   |
|                     | MOV.B @ERs+,Rd         | 1                 |              |                 | 1                |                  | 1                  |   |
|                     | MOV.B @aa:8,Rd         | 1                 |              |                 | 1                |                  |                    |   |
|                     | MOV.B @aa:16,Rd        | 2                 |              |                 | 1                |                  |                    |   |
|                     | MOV.B @aa:32,Rd        | 3                 |              |                 | 1                |                  |                    |   |
|                     | MOV.B Rs,@ERd          | 1                 |              |                 | 1                |                  |                    |   |
|                     | MOV.B Rs,@(d:16,ERd)   | 2                 |              |                 | 1                |                  |                    |   |
|                     | MOV.B Rs,@(d:32,ERd)   | 4                 |              |                 | 1                |                  |                    |   |
|                     | MOV.B Rs,@-ERd         | 1                 |              |                 | 1                |                  | 1                  |   |
|                     | MOV.B Rs,@aa:8         | 1                 |              |                 | 1                |                  |                    |   |
|                     | MOV.B Rs,@aa:16        | 2                 |              |                 | 1                |                  |                    |   |
|                     | MOV.B Rs,@aa:32        | 3                 |              |                 | 1                |                  |                    |   |
|                     | MOV.W #xx:16,Rd        | 2                 |              |                 |                  |                  |                    |   |
|                     | MOV.W Rs,Rd            | 1                 |              |                 |                  |                  |                    |   |
|                     | MOV.W @ERs,Rd          | 1                 |              |                 |                  |                  | 1                  |   |
|                     | MOV.W @(d:16,ERs),Rd   | 2                 |              |                 |                  |                  | 1                  |   |
|                     | MOV.W @(d:32,ERs),Rd   | 4                 |              |                 |                  |                  | 1                  |   |
|                     | MOV.W @ERs+,Rd         | 1                 |              |                 |                  |                  | 1                  | 1 |
|                     | MOV.W @aa:16,Rd        | 2                 |              |                 |                  |                  | 1                  |   |
|                     | MOV.W @aa:32,Rd        | 3                 |              |                 |                  |                  | 1                  |   |
|                     | MOV.W Rs,@ERd          | 1                 |              |                 |                  |                  | 1                  |   |

## Section 2 Instruction Descriptions

| Instruction | Mnemonic              | Instruction<br>Fetch | Branch          |                    |                       | Byte Data<br>Access | Word Data<br>Access            | Internal<br>Operation |
|-------------|-----------------------|----------------------|-----------------|--------------------|-----------------------|---------------------|--------------------------------|-----------------------|
|             |                       |                      | Address<br>Read | Stack<br>Operation | Internal<br>Operation |                     |                                |                       |
|             |                       | I                    | J               | K                  | L                     | M                   | N                              |                       |
| MOV         | MOV.W Rs,@(d:16,ERd)  | 2                    |                 |                    |                       | 1                   |                                |                       |
|             | MOV.W Rs,@(d:32,ERd)  | 4                    |                 |                    |                       | 1                   |                                |                       |
|             | MOV.W Rs,@-ERd        | 1                    |                 |                    |                       | 1                   | 1                              |                       |
|             | MOV.W Rs,@aa:16       | 2                    |                 |                    |                       | 1                   |                                |                       |
|             | MOV.W Rs,@aa:32       | 3                    |                 |                    |                       | 1                   |                                |                       |
|             | MOV.L #xx:32,ERd      | 3                    |                 |                    |                       |                     |                                |                       |
|             | MOV.L ERs,ERd         | 1                    |                 |                    |                       |                     |                                |                       |
|             | MOV.L @ERs,ERd        | 2                    |                 |                    |                       |                     | 2                              |                       |
|             | MOV.L @(d:16,ERs),ERd | 3                    |                 |                    |                       |                     | 2                              |                       |
|             | MOV.L @(d:32,ERs),ERd | 5                    |                 |                    |                       |                     | 2                              |                       |
|             | MOV.L @ERs+,ERd       | 2                    |                 |                    |                       |                     | 2                              | 1                     |
|             | MOV.L @aa:16,ERd      | 3                    |                 |                    |                       |                     | 2                              |                       |
|             | MOV.L @aa:32,ERd      | 4                    |                 |                    |                       |                     | 2                              |                       |
|             | MOV.L ERs,@ERd        | 2                    |                 |                    |                       |                     | 2                              |                       |
|             | MOV.L ERs,@(d:16,ERd) | 3                    |                 |                    |                       |                     | 2                              |                       |
|             | MOV.L ERs,@(d:32,ERd) | 5                    |                 |                    |                       |                     | 2                              |                       |
|             | MOV.L ERs,@-ERd       | 2                    |                 |                    |                       |                     | 2                              | 1                     |
|             | MOV.L ERs,@aa:16      | 3                    |                 |                    |                       |                     | 2                              |                       |
|             | MOV.L ERs,@aa:32      | 4                    |                 |                    |                       |                     | 2                              |                       |
| MOVFPPE     | MOVFPPE @aa:16,Rd     | 2                    |                 |                    |                       | 1* <sup>2</sup>     |                                |                       |
| MOVTPPE     | MOVTPPE Rs,@aa:16     | 2                    |                 |                    |                       | 1* <sup>2</sup>     |                                |                       |
| MULXS       | MULXS.B Rs,Rd         | H8S/2600             | 2               |                    |                       |                     | 2* <sup>3</sup> * <sup>6</sup> |                       |
|             |                       | H8S/2000             | 2               |                    |                       |                     | 11                             |                       |
|             | MULXS.W Rs,ERd        | H8S/2600             | 2               |                    |                       |                     | 3* <sup>3</sup> * <sup>6</sup> |                       |
|             |                       | H8S/2000             | 2               |                    |                       |                     | 19                             |                       |
| MULXU       | MULXU.B Rs,Rd         | H8S/2600             | 1               |                    |                       |                     | 2* <sup>3</sup> * <sup>6</sup> |                       |
|             |                       | H8S/2000             | 1               |                    |                       |                     | 11                             |                       |
|             | MULXU.W Rs,ERd        | H8S/2600             | 1               |                    |                       |                     | 3* <sup>3</sup> * <sup>6</sup> |                       |
|             |                       | H8S/2000             | 1               |                    |                       |                     | 19                             |                       |
| NEG         | NEG.B Rd              | 1                    |                 |                    |                       |                     |                                |                       |
|             | NEG.W Rd              | 1                    |                 |                    |                       |                     |                                |                       |
|             | NEG.L ERd             | 1                    |                 |                    |                       |                     |                                |                       |
| NOP         | NOP                   | 1                    |                 |                    |                       |                     |                                |                       |
| NOT         | NOT.B Rd              | 1                    |                 |                    |                       |                     |                                |                       |
|             | NOT.W Rd              | 1                    |                 |                    |                       |                     |                                |                       |
|             | NOT.L ERd             | 1                    |                 |                    |                       |                     |                                |                       |

| Instruction | Mnemonic        | Instruction Fetch | Branch       |                   |                  |                  |                    |
|-------------|-----------------|-------------------|--------------|-------------------|------------------|------------------|--------------------|
|             |                 |                   | Address Read | Stack Operation   | Byte Data Access | Word Data Access | Internal Operation |
|             |                 | I                 | J            | K                 | L                | M                | N                  |
| OR          | OR.B #xx:8,Rd   | 1                 |              |                   |                  |                  |                    |
|             | OR.B Rs,Rd      | 1                 |              |                   |                  |                  |                    |
|             | OR.W #xx:16,Rd  | 2                 |              |                   |                  |                  |                    |
|             | OR.W Rs,Rd      | 1                 |              |                   |                  |                  |                    |
|             | OR.L #xx:32,ERd | 3                 |              |                   |                  |                  |                    |
|             | OR.L ERs,ERd    | 2                 |              |                   |                  |                  |                    |
| ORC         | ORC #xx:8,CCR   | 1                 |              |                   |                  |                  |                    |
|             | ORC #xx:8,EXR   | 2                 |              |                   |                  |                  |                    |
| POP         | POP.W Rn        | 1                 |              |                   |                  | 1                | 1                  |
|             | POP.L ERn       | 2                 |              |                   |                  | 2                | 1                  |
| PUSH        | PUSH.W Rn       | 1                 |              |                   |                  | 1                | 1                  |
|             | PUSH.L ERn      | 2                 |              |                   |                  | 2                | 1                  |
| ROTL        | ROTL.B Rd       | 1                 |              |                   |                  |                  |                    |
|             | ROTL.B #2,Rd    | 1                 |              |                   |                  |                  |                    |
|             | ROTL.W Rd       | 1                 |              |                   |                  |                  |                    |
|             | ROTL.W #2,Rd    | 1                 |              |                   |                  |                  |                    |
|             | ROTL.L ERd      | 1                 |              |                   |                  |                  |                    |
|             | ROTL.L #2,ERd   | 1                 |              |                   |                  |                  |                    |
| ROTR        | ROTR.B Rd       | 1                 |              |                   |                  |                  |                    |
|             | ROTR.B #2,Rd    | 1                 |              |                   |                  |                  |                    |
|             | ROTR.W Rd       | 1                 |              |                   |                  |                  |                    |
|             | ROTR.W #2,Rd    | 1                 |              |                   |                  |                  |                    |
|             | ROTR.L ERd      | 1                 |              |                   |                  |                  |                    |
|             | ROTR.L #2,ERd   | 1                 |              |                   |                  |                  |                    |
| ROTXL       | ROTXL.B Rd      | 1                 |              |                   |                  |                  |                    |
|             | ROTXL.B #2,Rd   | 1                 |              |                   |                  |                  |                    |
|             | ROTXL.W Rd      | 1                 |              |                   |                  |                  |                    |
|             | ROTXL.W #2,Rd   | 1                 |              |                   |                  |                  |                    |
|             | ROTXL.L ERd     | 1                 |              |                   |                  |                  |                    |
|             | ROTXL.L #2,ERd  | 1                 |              |                   |                  |                  |                    |
| ROTXR       | ROTXR.B Rd      | 1                 |              |                   |                  |                  |                    |
|             | ROTXR.B #2,Rd   | 1                 |              |                   |                  |                  |                    |
|             | ROTXR.W Rd      | 1                 |              |                   |                  |                  |                    |
|             | ROTXR.W #2,Rd   | 1                 |              |                   |                  |                  |                    |
|             | ROTXR.L ERd     | 1                 |              |                   |                  |                  |                    |
|             | ROTXR.L #2,ERd  | 1                 |              |                   |                  |                  |                    |
| RTE         | RTE             | 2                 |              | 2/3 <sup>*1</sup> |                  |                  | 1                  |
| RTS         | RTS             | Normal            | 2            |                   | 1                |                  | 1                  |
|             |                 | Advanced          | 2            |                   | 2                |                  | 1                  |

| Instruction | Mnemonic              | Instruction<br>Fetch | Branch          | Stack<br>Operation | Byte Data<br>Access | Word Data<br>Access | Internal<br>Operation |
|-------------|-----------------------|----------------------|-----------------|--------------------|---------------------|---------------------|-----------------------|
|             |                       |                      | Address<br>Read |                    |                     |                     |                       |
|             |                       | I                    | J               | K                  | L                   | M                   | N                     |
| SHAL        | SHAL.B Rd             | 1                    |                 |                    |                     |                     |                       |
|             | SHAL.B #2,Rd          | 1                    |                 |                    |                     |                     |                       |
|             | SHAL.W Rd             | 1                    |                 |                    |                     |                     |                       |
|             | SHAL.W #2,Rd          | 1                    |                 |                    |                     |                     |                       |
|             | SHAL.L ERd            | 1                    |                 |                    |                     |                     |                       |
|             | SHAL.L #2,ERd         | 1                    |                 |                    |                     |                     |                       |
| SHAR        | SHAR.B Rd             | 1                    |                 |                    |                     |                     |                       |
|             | SHAR.B #2,Rd          | 1                    |                 |                    |                     |                     |                       |
|             | SHAR.W Rd             | 1                    |                 |                    |                     |                     |                       |
|             | SHAR.W #2,Rd          | 1                    |                 |                    |                     |                     |                       |
|             | SHAR.L ERd            | 1                    |                 |                    |                     |                     |                       |
|             | SHAR.L #2,ERd         | 1                    |                 |                    |                     |                     |                       |
| SHLL        | SHLL.B Rd             | 1                    |                 |                    |                     |                     |                       |
|             | SHLL.B #2,Rd          | 1                    |                 |                    |                     |                     |                       |
|             | SHLL.W Rd             | 1                    |                 |                    |                     |                     |                       |
|             | SHLL.W #2,Rd          | 1                    |                 |                    |                     |                     |                       |
|             | SHLL.L ERd            | 1                    |                 |                    |                     |                     |                       |
|             | SHLL.L #2,ERd         | 1                    |                 |                    |                     |                     |                       |
| SHLR        | SHLR.B Rd             | 1                    |                 |                    |                     |                     |                       |
|             | SHLR.B #2,Rd          | 1                    |                 |                    |                     |                     |                       |
|             | SHLR.W Rd             | 1                    |                 |                    |                     |                     |                       |
|             | SHLR.W #2,Rd          | 1                    |                 |                    |                     |                     |                       |
|             | SHLR.L ERd            | 1                    |                 |                    |                     |                     |                       |
|             | SHLR.L #2,ERd         | 1                    |                 |                    |                     |                     |                       |
| SLEEP       | SLEEP                 | 1                    |                 |                    |                     |                     | 1                     |
| STC         | STC.B CCR,Rd          | 1                    |                 |                    |                     |                     |                       |
|             | STC.B EXR,Rd          | 1                    |                 |                    |                     |                     |                       |
|             | STC.W CCR,@ERd        | 2                    |                 |                    |                     | 1                   |                       |
|             | STC.W EXR,@ERd        | 2                    |                 |                    |                     | 1                   |                       |
|             | STC.W CCR,@(d:16,ERd) | 3                    |                 |                    |                     | 1                   |                       |
|             | STC.W EXR,@(d:16,ERd) | 3                    |                 |                    |                     | 1                   |                       |
|             | STC.W CCR,@(d:32,ERd) | 5                    |                 |                    |                     | 1                   |                       |
|             | STC.W EXR,@(d:32,ERd) | 5                    |                 |                    |                     | 1                   |                       |
|             | STC.W CCR,@-ERd       | 2                    |                 |                    |                     | 1                   | 1                     |
|             | STC.W EXR,@-ERd       | 2                    |                 |                    |                     | 1                   | 1                     |
|             | STC.W CCR,@aa:16      | 3                    |                 |                    |                     | 1                   |                       |
|             | STC.W EXR,@aa:16      | 3                    |                 |                    |                     | 1                   |                       |
|             | STC.W CCR,@aa:32      | 4                    |                 |                    |                     | 1                   |                       |
|             | STC.W EXR,@aa:32      | 4                    |                 |                    |                     | 1                   |                       |



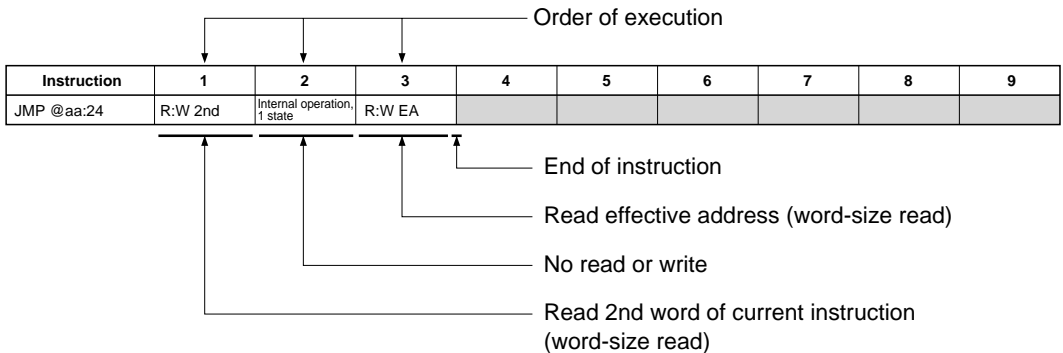
| Instruction | Mnemonic               | Instruction Fetch | Branch       | Stack Operation | Byte Data Access | Word Data Access | Internal Operation |
|-------------|------------------------|-------------------|--------------|-----------------|------------------|------------------|--------------------|
|             |                        |                   | Address Read |                 |                  |                  |                    |
|             |                        | I                 | J            | K               | L                | M                | N                  |
| STM         | STM.L (ERn-ERn+1),@-SP | 2                 |              | 4               |                  |                  | 1                  |
|             | STM.L(ERn-ERn+2),@-SP  | 2                 |              | 6               |                  |                  | 1                  |
|             | STM.L(ERn-ERn+3),@-SP  | 2                 |              | 8               |                  |                  | 1                  |
| STMAC*5     | STMAC MACH,ERd         | 1                 |              |                 |                  |                  | 0*3*6              |
|             | STMAC MACL,ERd         | 1                 |              |                 |                  |                  | 0*3*6              |
| SUB         | SUB.B Rs,Rd            | 1                 |              |                 |                  |                  |                    |
|             | SUB.W #xx:16,Rd        | 2                 |              |                 |                  |                  |                    |
|             | SUB.W Rs,Rd            | 1                 |              |                 |                  |                  |                    |
|             | SUB.L #xx:32,ERd       | 3                 |              |                 |                  |                  |                    |
|             | SUB.L ERs,ERd          | 1                 |              |                 |                  |                  |                    |
| SUBS        | SUBS #1/2/4,ERd        | 1                 |              |                 |                  |                  |                    |
| SUBX        | SUBX #xx:8,Rd          | 1                 |              |                 |                  |                  |                    |
|             | SUBX Rs,Rd             | 1                 |              |                 |                  |                  |                    |
| TAS         | TAS @ERd*4             | 2                 |              |                 | 2                |                  |                    |
| TRAPA       | TRAPA #x:2             | Normal            | 2            | 1               | 2/3*1            |                  | 2                  |
|             |                        | Advanced          | 2            | 2               | 2/3*1            |                  | 2                  |
| XOR         | XOR.B #xx:8,Rd         | 1                 |              |                 |                  |                  |                    |
|             | XOR.B Rs,Rd            | 1                 |              |                 |                  |                  |                    |
|             | XOR.W #xx:16,Rd        | 2                 |              |                 |                  |                  |                    |
|             | XOR.W Rs,Rd            | 1                 |              |                 |                  |                  |                    |
|             | XOR.L #xx:32,ERd       | 3                 |              |                 |                  |                  |                    |
|             | XOR.L ERs,ERd          | 2                 |              |                 |                  |                  |                    |
| XORC        | XORC #xx:8,CCR         | 1                 |              |                 |                  |                  |                    |
| XORC        | XORC #xx:8,EXR         | 2                 |              |                 |                  |                  |                    |

- Notes:
- 2 when EXR is invalid, 3 when EXR is valid.
  - 5 for concatenated execution, 4 otherwise.
  - An internal operation may require between 0 and 3 additional states, depending on the preceding instruction.
  - Only register ER0, ER1, ER4, or ER5 should be used when using the TAS instruction.
  - These instructions are supported by the H8S/2600 CPU only.
  - The number of states may differ depending on the product. For details, refer to the relevant microcontroller hardware manual of the product in question.

## 2.7 Bus States During Instruction Execution

Table 2.6 indicates the types of cycles that occur during instruction execution by the CPU. See table 2.4 for the number of states per cycle.

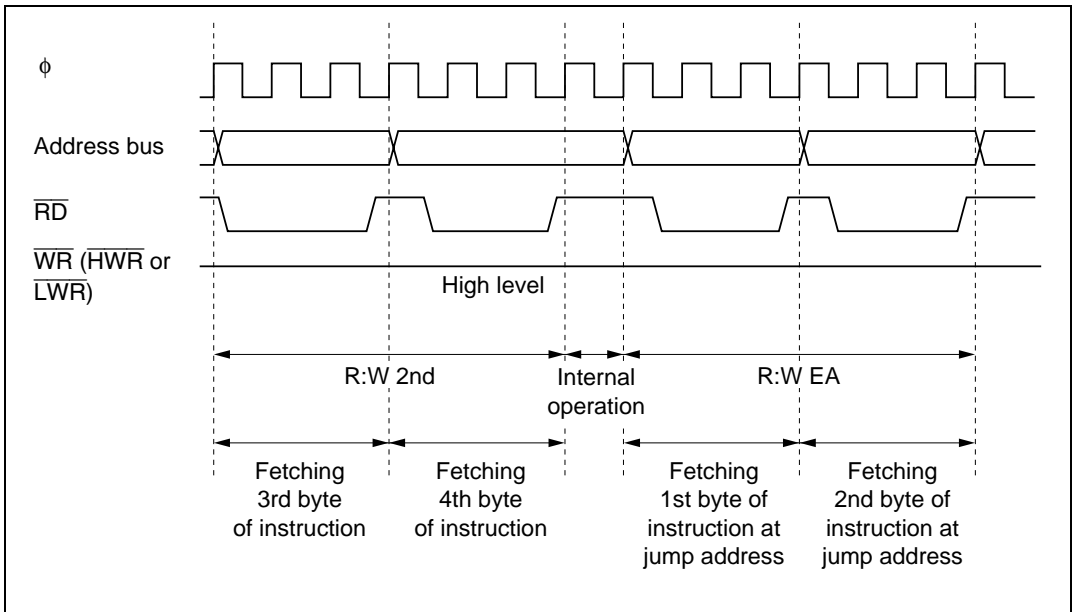
### How to Read the Table:



### Legend

|      |  |
|------|--|
| R:B  | Byte-size read                           |
| R:W  | Word-size read                           |
| W:B  | Byte-size write                          |
| W:W  | Word-size write                          |
| 2nd  | Address of 2nd word (3rd and 4th bytes)  |
| 3rd  | Address of 3rd word (5th and 6th bytes)  |
| 4th  | Address of 4th word (7th and 8th bytes)  |
| 5th  | Address of 5th word (9th and 10th bytes) |
| NEXT | Address of next instruction              |
| EA   | Effective address                        |
| VEC  | Vector address                           |

Figure 2.1 shows timing waveforms for the address bus and the  $\overline{RD}$  and  $\overline{WR}$  ( $\overline{HWR}$  or  $\overline{LWR}$ ) signals during execution of the above instruction with an 8-bit bus, using three-state access with no wait states.



**Figure 2.1 Address Bus,  $\overline{RD}$ , and  $\overline{WR}$  ( $\overline{HWR}$  or  $\overline{LWR}$ ) Timing (8-Bit Bus, Three-State Access, No Wait States)**

Table 2.6 Instruction Execution Cycles

| Instruction       | 1        | 2        | 3        | 4        | 5        | 6 | 7 | 8 | 9 |
|-------------------|----------|----------|----------|----------|----------|---|---|---|---|
| ADD.B #xx:8,Rd    | R:W NEXT |          |          |          |          |   |   |   |   |
| ADD.B Rs,Rd       | R:W NEXT |          |          |          |          |   |   |   |   |
| ADD.W #xx:16,Rd   | R:W 2nd  | R:W NEXT |          |          |          |   |   |   |   |
| ADD.W Rs,Rd       | R:W NEXT |          |          |          |          |   |   |   |   |
| ADD.L #xx:32,ERd  | R:W 2nd  | R:W 3rd  | R:W NEXT |          |          |   |   |   |   |
| ADD.L ERs,ERd     | R:W NEXT |          |          |          |          |   |   |   |   |
| ADDS #1/2/4,ERd   | R:W NEXT |          |          |          |          |   |   |   |   |
| ADDX #xx:8,Rd     | R:W NEXT |          |          |          |          |   |   |   |   |
| ADDX Rs,Rd        | R:W NEXT |          |          |          |          |   |   |   |   |
| AND.B #xx:8,Rd    | R:W NEXT |          |          |          |          |   |   |   |   |
| AND.B Rs,Rd       | R:W NEXT |          |          |          |          |   |   |   |   |
| AND.W #xx:16,Rd   | R:W 2nd  | R:W NEXT |          |          |          |   |   |   |   |
| AND.W Rs,Rd       | R:W NEXT |          |          |          |          |   |   |   |   |
| AND.L #xx:32,ERd  | R:W 2nd  | R:W 3rd  | R:W NEXT |          |          |   |   |   |   |
| AND.L ERs,ERd     | R:W 2nd  | R:W NEXT |          |          |          |   |   |   |   |
| ANDC #xx:8,CCR    | R:W NEXT |          |          |          |          |   |   |   |   |
| ANDC #xx:8,EXR    | R:W 2nd  | R:W NEXT |          |          |          |   |   |   |   |
| BAND #xx:3,Rd     | R:W NEXT |          |          |          |          |   |   |   |   |
| BAND #xx:3,@ERd   | R:W 2nd  | R:W NEXT |          |          |          |   |   |   |   |
| BAND #xx:3,@aa:8  | R:W 2nd  | R:W NEXT |          |          |          |   |   |   |   |
| BAND #xx:3,@aa:16 | R:W 2nd  | R:W 3rd  | R:W NEXT | R:W NEXT |          |   |   |   |   |
| BAND #xx:3,@aa:32 | R:W 2nd  | R:W 3rd  | R:W 4th  | R:W NEXT | R:W NEXT |   |   |   |   |
| BRA d:8 (BT d:8)  | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BRN d:8 (BF d:8)  | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BHI d:8           | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BLS d:8           | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BCC d:8 (BHS d:8) | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BCS d:8 (BLO d:8) | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BNE d:8           | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BEQ d:8           | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BVC d:8           | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BVS d:8           | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BPL d:8           | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BMI d:8           | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BGE d:8           | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BLT d:8           | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |
| BGT d:8           | R:W NEXT | R:W EA   |          |          |          |   |   |   |   |

| Instruction         | 1                  | 2  | 3        | 4        | 5      | 6 | 7 | 8 | 9 |
|---------------------|--------------------|--|----------|----------|--------|---|---|---|---|
| BLE d:8             | R:W NEXT           | R:W EA                                   |          |          |        |   |   |   |   |
| BRA d:16 (BT d:16)  | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BRN d:16 (BF d:16)  | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BHI d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BLS d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BCC d:16 (BHS d:16) | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BCS d:16 (BLO d:16) | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BNE d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BEQ d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BVC d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BVS d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BPL d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BMI d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BGE d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BLT d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BGT d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BLE d:16            | R:W 2nd<br>1 state | Internal operation,<br>R:W EA<br>1 state |          |          |        |   |   |   |   |
| BCLR #xxx:3Rd       | R:W NEXT           |  |          |          |        |   |   |   |   |
| BCLR #xxx:3@ERd     | R:W 2nd            | R:W EA                                   | R:W NEXT | W/B EA   |        |   |   |   |   |
| BCLR #xxx:3@aa:8    | R:W 2nd            | R:W EA                                   | R:W NEXT | W/B EA   |        |   |   |   |   |
| BCLR #xxx:3@aa:16   | R:W 2nd            | R:W 3rd                                  | R:W EA   | R:W NEXT | W/B EA |   |   |   |   |

| Instruction        | 1        | 2       | 3        | 4        | 5        | 6      | 7 | 8 | 9 |
|--------------------|----------|---------|----------|----------|----------|--------|---|---|---|
| BCLR #xx:3,@aa:32  | R:W 2nd  | R:W 3rd | R:W 4th  | R:B EA   | R:W NEXT | W:B EA |   |   |   |
| BCLR Rn,Rd         | R:W NEXT |         |          |          |          |        |   |   |   |
| BCLR Rn,@ERd       | R:W 2nd  | R:B EA  | R:W NEXT | W:B EA   |          |        |   |   |   |
| BCLR Rn,@aa:8      | R:W 2nd  | R:B EA  | R:W NEXT | W:B EA   |          |        |   |   |   |
| BCLR Rn,@aa:16     | R:W 2nd  | R:W 3rd | R:B EA   | R:W NEXT | W:B EA   |        |   |   |   |
| BCLR Rn,@aa:32     | R:W 2nd  | R:W 3rd | R:W 4th  | R:B EA   | R:W NEXT | W:B EA |   |   |   |
| BAND #xx:3,Rd      | R:W NEXT |         |          |          |          |        |   |   |   |
| BAND #xx:3,@ERd    | R:W 2nd  | R:B EA  | R:W NEXT |          |          |        |   |   |   |
| BAND #xx:3,@aa:8   | R:W 2nd  | R:B EA  | R:W NEXT |          |          |        |   |   |   |
| BAND #xx:3,@aa:16  | R:W 2nd  | R:W 3rd | R:B EA   | R:W NEXT |          |        |   |   |   |
| BAND #xx:3,@aa:32  | R:W 2nd  | R:W 3rd | R:W 4th  | R:B EA   | R:W NEXT |        |   |   |   |
| BILD #xx:3,Rd      | R:W NEXT |         |          |          |          |        |   |   |   |
| BILD #xx:3,@ERd    | R:W 2nd  | R:B EA  | R:W NEXT |          |          |        |   |   |   |
| BILD #xx:3,@aa:8   | R:W 2nd  | R:B EA  | R:W NEXT |          |          |        |   |   |   |
| BILD #xx:3,@aa:16  | R:W 2nd  | R:W 3rd | R:B EA   | R:W NEXT |          |        |   |   |   |
| BILD #xx:3,@aa:32  | R:W 2nd  | R:W 3rd | R:W 4th  | R:B EA   | R:W NEXT |        |   |   |   |
| BIOR #xx:3,Rd      | R:W NEXT |         |          |          |          |        |   |   |   |
| BIOR #xx:3,@ERd    | R:W 2nd  | R:B EA  | R:W NEXT |          |          |        |   |   |   |
| BIOR #xx:3,@aa:8   | R:W 2nd  | R:B EA  | R:W NEXT |          |          |        |   |   |   |
| BIOR #xx:3,@aa:16  | R:W 2nd  | R:W 3rd | R:B EA   | R:W NEXT |          |        |   |   |   |
| BIOR #xx:3,@aa:32  | R:W 2nd  | R:W 3rd | R:W 4th  | R:B EA   | R:W NEXT |        |   |   |   |
| BIST #xx:3,Rd      | R:W NEXT |         |          |          |          |        |   |   |   |
| BIST #xx:3,@ERd    | R:W 2nd  | R:B EA  | R:W NEXT | W:B EA   |          |        |   |   |   |
| BIST #xx:3,@aa:8   | R:W 2nd  | R:B EA  | R:W NEXT | W:B EA   |          |        |   |   |   |
| BIST #xx:3,@aa:16  | R:W 2nd  | R:W 3rd | R:B EA   | R:W NEXT | W:B EA   |        |   |   |   |
| BIST #xx:3,@aa:32  | R:W 2nd  | R:W 3rd | R:W 4th  | R:B EA   | R:W NEXT | W:B EA |   |   |   |
| BIXOR #xx:3,Rd     | R:W NEXT |         |          |          |          |        |   |   |   |
| BIXOR #xx:3,@ERd   | R:W 2nd  | R:B EA  | R:W NEXT |          |          |        |   |   |   |
| BIXOR #xx:3,@aa:8  | R:W 2nd  | R:B EA  | R:W NEXT |          |          |        |   |   |   |
| BIXOR #xx:3,@aa:16 | R:W 2nd  | R:W 3rd | R:B EA   | R:W NEXT |          |        |   |   |   |
| BIXOR #xx:3,@aa:32 | R:W 2nd  | R:W 3rd | R:W 4th  | R:B EA   | R:W NEXT |        |   |   |   |
| BLD #xx:3,Rd       | R:W NEXT |         |          |          |          |        |   |   |   |
| BLD #xx:3,@ERd     | R:W 2nd  | R:B EA  | R:W NEXT |          |          |        |   |   |   |
| BLD #xx:3,@aa:8    | R:W 2nd  | R:B EA  | R:W NEXT |          |          |        |   |   |   |
| BLD #xx:3,@aa:16   | R:W 2nd  | R:W 3rd | R:B EA   | R:W NEXT |          |        |   |   |   |
| BLD #xx:3,@aa:32   | R:W 2nd  | R:W 3rd | R:W 4th  | R:B EA   | R:W NEXT |        |   |   |   |
| BNOT #xx:3,Rd      | R:W NEXT |         |          |          |          |        |   |   |   |

| Instruction       | 1        | 2        | 3                             | 4             | 5             | 6             | 7 | 8 | 9 |
|-------------------|----------|----------|-------------------------------|---------------|---------------|---------------|---|---|---|
| BNOT #xx:3,@ERd   | R:W 2nd  | R:B EA   | R:W NEXT                      | W/B EA        |               |               |   |   |   |
| BNOT #xx:3,@aa:8  | R:W 2nd  | R:B EA   | R:W NEXT                      | W/B EA        |               |               |   |   |   |
| BNOT #xx:3,@aa:16 | R:W 2nd  | R:W 3rd  | R:B EA                        | R:W NEXT      | W/B EA        |               |   |   |   |
| BNOT #xx:3,@aa:32 | R:W 2nd  | R:W 3rd  | R:W 4th                       | R:B EA        | R:W NEXT      | W/B EA        |   |   |   |
| BNOT Rn,Rd        | R:W NEXT |          |                               |               |               |               |   |   |   |
| BNOT Rn,@ERd      | R:W 2nd  | R:B EA   | R:W NEXT                      | W/B EA        |               |               |   |   |   |
| BNOT Rn,@aa:8     | R:W 2nd  | R:B EA   | R:W NEXT                      | W/B EA        |               |               |   |   |   |
| BNOT Rn,@aa:16    | R:W 2nd  | R:W 3rd  | R:B EA                        | R:W NEXT      | W/B EA        |               |   |   |   |
| BNOT Rn,@aa:32    | R:W 2nd  | R:W 3rd  | R:W 4th                       | R:B EA        | R:W NEXT      | W/B EA        |   |   |   |
| BOR #xx:3,Rd      | R:W NEXT |          |                               |               |               |               |   |   |   |
| BOR #xx:3,@ERd    | R:W 2nd  | R:B EA   | R:W NEXT                      |               |               |               |   |   |   |
| BOR #xx:3,@aa:8   | R:W 2nd  | R:B EA   | R:W NEXT                      |               |               |               |   |   |   |
| BOR #xx:3,@aa:16  | R:W 2nd  | R:W 3rd  | R:B EA                        | R:W NEXT      |               |               |   |   |   |
| BOR #xx:3,@aa:32  | R:W 2nd  | R:W 3rd  | R:W 4th                       | R:B EA        | R:W NEXT      |               |   |   |   |
| BSET #xx:3,Rd     | R:W NEXT |          |                               |               |               |               |   |   |   |
| BSET #xx:3,@ERd   | R:W 2nd  | R:B EA   | R:W NEXT                      | W/B EA        |               |               |   |   |   |
| BSET #xx:3,@aa:8  | R:W 2nd  | R:B EA   | R:W NEXT                      | W/B EA        |               |               |   |   |   |
| BSET #xx:3,@aa:16 | R:W 2nd  | R:W 3rd  | R:B EA                        | R:W NEXT      | W/B EA        |               |   |   |   |
| BSET #xx:3,@aa:32 | R:W 2nd  | R:W 3rd  | R:W 4th                       | R:B EA        | R:W NEXT      | W/B EA        |   |   |   |
| BSET Rn,Rd        | R:W NEXT |          |                               |               |               |               |   |   |   |
| BSET Rn,@ERd      | R:W 2nd  | R:B EA   | R:W NEXT                      | W/B EA        |               |               |   |   |   |
| BSET Rn,@aa:8     | R:W 2nd  | R:B EA   | R:W NEXT                      | W/B EA        |               |               |   |   |   |
| BSET Rn,@aa:16    | R:W 2nd  | R:W 3rd  | R:B EA                        | R:W NEXT      | W/B EA        |               |   |   |   |
| BSET Rn,@aa:32    | R:W 2nd  | R:W 3rd  | R:W 4th                       | R:B EA        | R:W NEXT      | W/B EA        |   |   |   |
| BSR d:8           | Normal   | R:W EA   | W:W stack                     |               |               |               |   |   |   |
|                   | Advanced | R:W NEXT | W:W stack (H)                 | W:W stack (L) |               |               |   |   |   |
| BSR d:16          | Normal   | R:W 2nd  | Internal operation<br>1 state | R:W EA        | W:W stack     |               |   |   |   |
|                   | Advanced | R:W 2nd  | Internal operation<br>1 state | R:W EA        | W:W stack (H) | W:W stack (L) |   |   |   |
| BST #xx:3,Rd      | R:W NEXT |          |                               |               |               |               |   |   |   |
| BST #xx:3,@ERd    | R:W 2nd  | R:B EA   | R:W NEXT                      | W/B EA        |               |               |   |   |   |
| BST #xx:3,@aa:8   | R:W 2nd  | R:B EA   | R:W NEXT                      | W/B EA        |               |               |   |   |   |
| BST #xx:3,@aa:16  | R:W 2nd  | R:W 3rd  | R:B EA                        | R:W NEXT      | W/B EA        |               |   |   |   |
| BST #xx:3,@aa:32  | R:W 2nd  | R:W 3rd  | R:W 4th                       | R:B EA        | R:W NEXT      | W/B EA        |   |   |   |
| BTST #xx:3,Rd     | R:W NEXT |          |                               |               |               |               |   |   |   |
| BTST #xx:3,@ERd   | R:W 2nd  | R:B EA   | R:W NEXT                      |               |               |               |   |   |   |

| Instruction       | 1        | 2                                | 3                             | 4          | 5                       | 6        | 7 | 8 | 9 |
|-------------------|----------|----------------------------------|-------------------------------|------------|-------------------------|----------|---|---|---|
| BTST #xx:3,@aa:8  | R:W 2nd  | R:B EA                           | R:W NEXT                      |            |                         |          |   |   |   |
| BTST #xx:3,@aa:16 | R:W 2nd  | R:W 3rd                          | R:B EA                        | R:W NEXT   |                         |          |   |   |   |
| BTST #xx:3,@aa:32 | R:W 2nd  | R:W 3rd                          | R:W 4th                       | R:B EA     | R:W NEXT                |          |   |   |   |
| BTST Rn,Rd        | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| BTST Rn,@ERd      | R:W 2nd  | R:B EA                           | R:W NEXT                      |            |                         |          |   |   |   |
| BTST Rn,@aa:8     | R:W 2nd  | R:B EA                           | R:W NEXT                      |            |                         |          |   |   |   |
| BTST Rn,@aa:16    | R:W 2nd  | R:W 3rd                          | R:B EA                        | R:W NEXT   |                         |          |   |   |   |
| BTST Rn,@aa:32    | R:W 2nd  | R:W 3rd                          | R:W 4th                       | R:B EA     | R:W NEXT                |          |   |   |   |
| BXOR #xx:3,Rd     | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| BXOR #xx:3,@ERd   | R:W 2nd  | R:B EA                           | R:W NEXT                      |            |                         |          |   |   |   |
| BXOR #xx:3,@aa:8  | R:W 2nd  | R:B EA                           | R:W NEXT                      |            |                         |          |   |   |   |
| BXOR #xx:3,@aa:16 | R:W 2nd  | R:W 3rd                          | R:B EA                        | R:W NEXT   |                         |          |   |   |   |
| BXOR #xx:3,@aa:32 | R:W 2nd  | R:W 3rd                          | R:W 4th                       | R:B EA     | R:W NEXT                |          |   |   |   |
| CLRMAC*           | R:W NEXT | Internal operation,<br>1 state*9 |                               |            |                         |          |   |   |   |
| CMPB #xx:8,Rd     | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| CMPB Rs,Rd        | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| CMPW #xx:16,Rd    | R:W 2nd  | R:W NEXT                         |                               |            |                         |          |   |   |   |
| CMPW Rs,Rd        | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| CMP.L #xx:32,ERd  | R:W 2nd  | R:W 3rd                          | R:W NEXT                      |            |                         |          |   |   |   |
| CMP.L ERs,ERd     | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| DAA Rd            | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| DAS Rd            | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| DEC.B Rd          | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| DEC.W #1/2,Rd     | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| DECL #1/2,ERd     | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| DIVXS.B Rs,Rd     | R:W 2nd  | R:W NEXT                         | Internal operation, 11 states |            |                         |          |   |   |   |
| DIVXS.W Rs,ERd    | R:W 2nd  | R:W NEXT                         | Internal operation, 19 states |            |                         |          |   |   |   |
| DIVXU.B Rs,Rd     | R:W NEXT | Internal operation, 11 states    |                               |            |                         |          |   |   |   |
| DIVXU.W Rs,ERd    | R:W NEXT | Internal operation, 19 states    |                               |            |                         |          |   |   |   |
| EEPMOVB           | R:W 2nd  | R:B EAs *1                       | R:B EAd *1                    | R:B EAs *2 | W:B EAd *2              | R:W NEXT |   |   |   |
| EEPMOVW           | R:W 2nd  | R:B EAs *1                       | R:B EAd *1                    | R:B EAs *2 | W:B EAd *2              | R:W NEXT |   |   |   |
| EXTS.W Rd         | R:W NEXT |                                  |                               |            | ← Repeated n times *3 → |          |   |   |   |
| EXTS.L ERd        | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| EXTU.W Rd         | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| EXTU.L ERd        | R:W NEXT |                                  |                               |            |                         |          |   |   |   |
| INC.B Rd          | R:W NEXT |                                  |                               |            |                         |          |   |   |   |



| Instruction            | 1        | 2                              | 3                              | 4                              | 5                          | 6      | 7 | 8 | 9 |
|------------------------|----------|--------------------------------|--------------------------------|--------------------------------|----------------------------|--------|---|---|---|
| INC.W #1/2,Rd          | R:W NEXT |                                |                                |                                |                            |        |   |   |   |
| INCL.#1/2,ERd          | R:W NEXT |                                |                                |                                |                            |        |   |   |   |
| JMP @ERn               | R:W NEXT | R:W EA                         |                                |                                |                            |        |   |   |   |
| JMP @aa:24             | R:W 2nd  | Internal operation,<br>1 state | R:W EA                         |                                |                            |        |   |   |   |
| JMP @aa:8              | R:W NEXT | R:W aa:8                       | Internal operation,<br>1 state | R:W EA                         |                            |        |   |   |   |
|                        | Advanced | R:W aa:8 (H)                   | R:W aa:8 (L)                   | Internal operation,<br>1 state | R:W EA                     |        |   |   |   |
| JSR @ERn               | R:W NEXT | R:W EA                         | W:W stack                      |                                |                            |        |   |   |   |
|                        | Advanced | R:W EA                         | W:W stack (H)                  | W:W stack (L)                  |                            |        |   |   |   |
| JSR @aa:24             | R:W 2nd  | Internal operation,<br>1 state | R:W EA                         | W:W stack                      |                            |        |   |   |   |
|                        | Advanced | Internal operation,<br>1 state | R:W EA                         | W:W stack (H)                  | W:W stack (L)              |        |   |   |   |
| JSR @aa:8              | R:W NEXT | R:W aa:8                       | W:W stack                      | R:W EA                         |                            |        |   |   |   |
|                        | Advanced | R:W aa:8 (H)                   | R:W aa:8 (L)                   | W:W stack (H)                  | W:W stack (L)              | R:W EA |   |   |   |
| LDC #x:8,CCR           | R:W NEXT |                                |                                |                                |                            |        |   |   |   |
| LDC #x:8,EXR           | R:W 2nd  | R:W NEXT                       |                                |                                |                            |        |   |   |   |
| LDC Rs,CCR             | R:W NEXT |                                |                                |                                |                            |        |   |   |   |
| LDC Rs,EXR             | R:W NEXT |                                |                                |                                |                            |        |   |   |   |
| LDC @ERs,CCR           | R:W 2nd  | R:W NEXT                       | R:W EA                         |                                |                            |        |   |   |   |
| LDC @ERs,EXR           | R:W 2nd  | R:W NEXT                       | R:W EA                         |                                |                            |        |   |   |   |
| LDC @(d:16,ERs),CCR    | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | R:W EA                         |                            |        |   |   |   |
| LDC @(d:16,ERs),EXR    | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | R:W EA                         |                            |        |   |   |   |
| LDC @(d:32,ERs),CCR    | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W 5th                        | R:W NEXT                   | R:W EA |   |   |   |
| LDC @(d:32,ERs),EXR    | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W 5th                        | R:W NEXT                   | R:W EA |   |   |   |
| LDC @ERs+,CCR          | R:W 2nd  | R:W NEXT                       | Internal operation,<br>1 state | R:W EA                         |                            |        |   |   |   |
|                        |          | R:W NEXT                       | Internal operation,<br>1 state | R:W EA                         |                            |        |   |   |   |
| LDC @ERs+,EXR          | R:W 2nd  | R:W NEXT                       | Internal operation,<br>1 state | R:W EA                         |                            |        |   |   |   |
|                        |          | R:W 3rd                        | R:W NEXT                       | R:W EA                         |                            |        |   |   |   |
| LDC @aa:16,CCR         | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | R:W EA                         |                            |        |   |   |   |
| LDC @aa:16,EXR         | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | R:W EA                         |                            |        |   |   |   |
| LDC @aa:32,CCR         | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W NEXT                       | R:W EA                     |        |   |   |   |
| LDC @aa:32,EXR         | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W NEXT                       | R:W EA                     |        |   |   |   |
| LDM.L @SP+,(ERn-ERn+1) | R:W 2nd  | R:W NEXT                       | Internal operation,<br>1 state | R:W stack (H) <sup>3</sup>     | R:W stack (L) <sup>3</sup> |        |   |   |   |

| Instruction                     | 1        | 2                                | 3                              | 4                          | 5                          | 6        | 7 | 8 | 9 |
|---------------------------------|----------|----------------------------------|--------------------------------|----------------------------|----------------------------|----------|---|---|---|
| LDM.L @SP+, (ERn-ERn+2)         | R:W 2nd  | R:W NEXT                         | Internal operation,<br>1 state | R:W stack (H) <sup>3</sup> | R:W stack (L) <sup>3</sup> |          |   |   |   |
| LDM.L @SP+, (ERn-ERn+3)         | R:W 2nd  | R:W NEXT                         | Internal operation,<br>1 state | R:W stack (H) <sup>3</sup> | R:W stack (L) <sup>3</sup> |          |   |   |   |
| LDMAC ERs, MACH <sup>*11</sup>  | R:W NEXT | Internal operation,<br>1 state*9 |                                | ← Repeated n times*3 →     |                            |          |   |   |   |
| LDMAC ERs, MACL <sup>*11</sup>  | R:W NEXT | Internal operation,<br>1 state*9 |                                |                            |                            |          |   |   |   |
| MAC @ERn+, @ERm+ <sup>*11</sup> | R:W 2nd  | R:W NEXT                         | R:W EAn                        | R:W EAm                    |                            |          |   |   |   |
| MOV.B #xx:8, Rd                 | R:W NEXT |                                  |                                |                            |                            |          |   |   |   |
| MOV.B Rs, Rd                    | R:W NEXT |                                  |                                |                            |                            |          |   |   |   |
| MOV.B @ERs, Rd                  | R:W NEXT | R:W NEXT                         | R:W NEXT                       | R:W NEXT                   |                            |          |   |   |   |
| MOV.B @ERs, Rd                  | R:W 2nd  | R:W NEXT                         | R:W NEXT                       | R:W NEXT                   |                            |          |   |   |   |
| MOV.B @ERs, Rd                  | R:W 2nd  | R:W 2nd                          | R:W 3rd                        | R:W 4th                    | R:W NEXT                   | R:W NEXT |   |   |   |
| MOV.B @ERs+, Rd                 | R:W NEXT | Internal operation,<br>1 state   | Internal operation,<br>R:W EAn |                            |                            |          |   |   |   |
| MOV.B @ERs+, Rd                 | R:W NEXT | R:W NEXT                         | R:W NEXT                       |                            |                            |          |   |   |   |
| MOV.B @aa:8, Rd                 | R:W NEXT | R:W NEXT                         | R:W NEXT                       | R:W NEXT                   |                            |          |   |   |   |
| MOV.B @aa:16, Rd                | R:W 2nd  | R:W NEXT                         | R:W NEXT                       | R:W NEXT                   |                            |          |   |   |   |
| MOV.B @aa:32, Rd                | R:W 2nd  | R:W 3rd                          | R:W NEXT                       | R:W NEXT                   |                            |          |   |   |   |
| MOV.B Rs, @ERd                  | R:W NEXT | W:W EA                           |                                |                            |                            |          |   |   |   |
| MOV.B Rs, @ERd                  | R:W 2nd  | R:W NEXT                         | W:W EA                         |                            |                            |          |   |   |   |
| MOV.B Rs, @ERd                  | R:W 2nd  | R:W 3rd                          | R:W 4th                        | R:W NEXT                   | W:W EA                     |          |   |   |   |
| MOV.B Rs, @ERd                  | R:W NEXT | Internal operation,<br>1 state   | Internal operation,<br>W:W EA  |                            |                            |          |   |   |   |
| MOV.B Rs, @aa:8                 | R:W NEXT | W:W EA                           |                                |                            |                            |          |   |   |   |
| MOV.B Rs, @aa:16                | R:W 2nd  | R:W NEXT                         | W:W EA                         |                            |                            |          |   |   |   |
| MOV.B Rs, @aa:32                | R:W 2nd  | R:W 3rd                          | R:W NEXT                       | W:W EA                     |                            |          |   |   |   |
| MOV.W #xx:16, Rd                | R:W 2nd  | R:W NEXT                         |                                |                            |                            |          |   |   |   |
| MOV.W Rs, Rd                    | R:W NEXT |                                  |                                |                            |                            |          |   |   |   |
| MOV.W @ERs, Rd                  | R:W NEXT | R:W EA                           |                                |                            |                            |          |   |   |   |
| MOV.W @ERs, Rd                  | R:W 2nd  | R:W NEXT                         | R:W EA                         |                            |                            |          |   |   |   |
| MOV.W @ERs+, Rd                 | R:W 2nd  | R:W 3rd                          | R:W 4th                        | R:W NEXT                   | R:W EA                     |          |   |   |   |
| MOV.W @ERs+, Rd                 | R:W NEXT | Internal operation,<br>1 state   | Internal operation,<br>R:W EA  |                            |                            |          |   |   |   |
| MOV.W @aa:16, Rd                | R:W 2nd  | R:W NEXT                         | R:W EA                         |                            |                            |          |   |   |   |
| MOV.W @aa:32, Rd                | R:W 2nd  | R:W 3rd                          | R:W NEXT                       | R:W EA                     |                            |          |   |   |   |
| MOV.W Rs, @ERd                  | R:W NEXT | W:W EA                           |                                |                            |                            |          |   |   |   |

| Instruction          | 1        | 2                              | 3                              | 4        | 5        | 6        | 7        | 8 | 9 |
|----------------------|----------|--------------------------------|--------------------------------|----------|----------|----------|----------|---|---|
| MOVW Rs,@(d:16,ERd)  | R:W 2nd  | R:W NEXT                       | W:W EA                         |          |          |          |          |   |   |
| MOVW Rs,@(d:32,ERd)  | R:W 2nd  | R:W 3rd                        | R-E 4th                        | R:W NEXT | W:W EA   |          |          |   |   |
| MOVW Rs,@aa:16       | R:W 2nd  | R:W NEXT                       | W:W EA                         |          |          |          |          |   |   |
| MOVW Rs,@aa:32       | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | W:W EA   |          |          |          |   |   |
| MOVW Rs,@-ERd        | R:W NEXT | Internal operation, 1 state    | W:W EA                         |          |          |          |          |   |   |
| MOVL #x:32,ERd       | R:W 2nd  | R:W 3rd                        | R:W NEXT                       |          |          |          |          |   |   |
| MOVL ERs,ERd         | R:W NEXT |                                |                                |          |          |          |          |   |   |
| MOVL @ERs,ERd        | R:W 2nd  | R:W NEXT                       | R:W EA                         | R:W EA+2 |          |          |          |   |   |
| MOVL @(d:16,ERs),ERd | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | R:W EA   | R:W EA+2 |          |          |   |   |
| MOVL @(d:32,ERs),ERd | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W 5th  | R:W NEXT | R:W EA   | R:W EA+2 |   |   |
| MOVL @ERs+1,ERd      | R:W 2nd  | R:W NEXT                       | Internal operation, 1 state    | R:W EA   | R:W EA+2 |          |          |   |   |
| MOVL @aa:16,ERd      | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | R:W EA   | R:W EA+2 |          |          |   |   |
| MOVL @aa:32,ERd      | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W NEXT | R:W EA   | R:W EA+2 |          |   |   |
| MOVL ERs,@ERd        | R:W 2nd  | R:W NEXT                       | W:W EA                         | W:W EA+2 |          |          |          |   |   |
| MOVL ERs,@(d:16,ERd) | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | W:W EA   | W:W EA+2 |          |          |   |   |
| MOVL ERs,@(d:32,ERd) | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W 5th  | R:W NEXT | W:W EA   | W:W EA+2 |   |   |
| MOVL ERs,@-ERd       | R:W 2nd  | R:W NEXT                       | Internal operation, 1 state    | W:W EA   | W:W EA+2 |          |          |   |   |
| MOVL ERs,@aa:16      | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | W:W EA   | W:W EA+2 |          |          |   |   |
| MOVL ERs,@aa:32      | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W NEXT | W:W EA   | W:W EA+2 |          |   |   |
| MOVFPPE @aa:16,Rd    | R:W 2nd  | R:W NEXT                       | R:W *4 EA                      |          |          |          |          |   |   |
| MOVTPPE Rs,@aa:16    | R:W 2nd  | R:W NEXT                       | W:B *4 EA                      |          |          |          |          |   |   |
| MULXS.B Rs,Rd        | H8S/2600 | R:W NEXT                       | Internal operation, 2 states*9 |          |          |          |          |   |   |
| H8S/2000             | R:W 2nd  | R:W NEXT                       | Internal operation, 11 states  |          |          |          |          |   |   |
| H8S/2600             | R:W 2nd  | R:W NEXT                       | Internal operation, 3 states*9 |          |          |          |          |   |   |
| H8S/2000             | R:W 2nd  | R:W NEXT                       | Internal operation, 19 states  |          |          |          |          |   |   |
| MULXU.B Rs,Rd        | H8S/2000 | R:W NEXT                       | Internal operation, 2 states*9 |          |          |          |          |   |   |
| H8S/2600             | R:W NEXT | Internal operation, 11 states  |                                |          |          |          |          |   |   |
| H8S/2000             | R:W NEXT | Internal operation, 3 states*9 |                                |          |          |          |          |   |   |
| H8S/2600             | R:W NEXT | Internal operation, 19 states  |                                |          |          |          |          |   |   |
| NEG.B Rd             | R:W NEXT |                                |                                |          |          |          |          |   |   |
| NEG.W Rd             | R:W NEXT |                                |                                |          |          |          |          |   |   |
| NEG.L ERd            | R:W NEXT |                                |                                |          |          |          |          |   |   |
| NOP                  | R:W NEXT |                                |                                |          |          |          |          |   |   |
| NOT.B Rd             | R:W NEXT |                                |                                |          |          |          |          |   |   |

| Instruction     | 1        | 2                              | 3                              | 4      | 5        | 6 | 7 | 8 | 9 |
|-----------------|----------|--------------------------------|--------------------------------|--------|----------|---|---|---|---|
| NOTW Rd         | R:W NEXT |                                |                                |        |          |   |   |   |   |
| NOTL ERd        | R:W NEXT |                                |                                |        |          |   |   |   |   |
| OR.B #xx:8,Rd   | R:W NEXT |                                |                                |        |          |   |   |   |   |
| OR.B Rs,Rd      | R:W NEXT |                                |                                |        |          |   |   |   |   |
| OR.W #xx:16,Rd  | R:W 2nd  | R:W NEXT                       |                                |        |          |   |   |   |   |
| OR.W Rs,Rd      | R:W NEXT |                                |                                |        |          |   |   |   |   |
| OR.L #xx:32,ERd | R:W 2nd  | R:W 3rd                        | R:W NEXT                       |        |          |   |   |   |   |
| OR.L ERs,ERd    | R:W 2nd  | R:W NEXT                       |                                |        |          |   |   |   |   |
| ORC #xx:8,CCR   | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ORC #xx:8,EXR   | R:W 2nd  | R:W NEXT                       |                                |        |          |   |   |   |   |
| POP:W Rn        | R:W NEXT | Internal operation,<br>1 state | R:W EA                         |        |          |   |   |   |   |
| POP:L ERn       | R:W 2nd  | R:W NEXT                       | Internal operation,<br>1 state | R:W EA | R:W EA+2 |   |   |   |   |
| PUSH:W Rn       | R:W NEXT | Internal operation,<br>1 state | W:W EA                         |        |          |   |   |   |   |
| PUSH:L ERn      | R:W 2nd  | R:W NEXT                       | Internal operation,<br>1 state | W:W EA | W:W EA+2 |   |   |   |   |
| ROTLB Rd        | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTLB #2,Rd     | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTL:W Rd       | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTL:W #2,Rd    | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTL:LL ERd     | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTL:LL #2,ERd  | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTR:B Rd       | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTR:B #2,Rd    | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTR:W Rd       | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTR:W #2,Rd    | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTR:L ERd      | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTR:L #2,ERd   | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTX:LB Rd      | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTX:LB #2,Rd   | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTX:W Rd       | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTX:W #2,Rd    | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTX:LL ERd     | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTX:LL #2,ERd  | R:W NEXT |                                |                                |        |          |   |   |   |   |
| ROTXR:B Rd      | R:W NEXT |                                |                                |        |          |   |   |   |   |

| Instruction    | 1        | 2                              | 3                              | 4                              | 5                              | 6      | 7 | 8 | 9 |
|----------------|----------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------|---|---|---|
| ROTXR.B #2,Rd  | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| ROTXR.W Rd     | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| ROTXR.W #2,Rd  | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| ROTXR.L ERd    | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| ROTXR.L #2,ERd | R:W NEXT | R:W stack (EXR)                | R:W stack (H)                  | R:W stack (L)                  | Internal operation,<br>1 state | R:W *5 |   |   |   |
| RTE            | R:W NEXT | R:W stack (EXR)                | R:W stack (H)                  | R:W stack (L)                  | Internal operation,<br>1 state | R:W *5 |   |   |   |
| RTS            | Normal   | R:W stack                      | Internal operation,<br>1 state | R:W *5                         |                                |        |   |   |   |
|                | Advanced | R:W stack (H)                  | R:W stack (L)                  | Internal operation,<br>1 state | R:W *5                         |        |   |   |   |
| SHALB Rd       | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHALB #2,Rd    | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHAL.W Rd      | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHAL.W #2,Rd   | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHALL ERd      | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHALL #2,ERd   | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHAR.B Rd      | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHAR.B #2,Rd   | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHAR.W Rd      | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHAR.W #2,Rd   | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHAR.L ERd     | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHAR.L #2,ERd  | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLL.B Rd      | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLL.B #2,Rd   | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLL.W Rd      | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLL.W #2,Rd   | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLL.L ERd     | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLL.L #2,ERd  | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLR.B Rd      | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLR.B #2,Rd   | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLR.W Rd      | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLR.W #2,Rd   | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLR.L ERd     | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SHLR.L #2,ERd  | R:W NEXT |                                |                                |                                |                                |        |   |   |   |
| SLEEP          | R:W NEXT | Internal operation,<br>1 state |                                |                                |                                |        |   |   |   |
| STC.CCR,Rd     | R:W NEXT |                                |                                |                                |                                |        |   |   |   |

| Instruction                   | 1        | 2                              | 3                              | 4                                  | 5                          | 6       | 7                              | 8                              | 9                 |
|-------------------------------|----------|--------------------------------|--------------------------------|------------------------------------|----------------------------|---------|--------------------------------|--------------------------------|-------------------|
| STC EXR.Rd                    | R:W NEXT |                                |                                |                                    |                            |         |                                |                                |                   |
| STC CCR.@ERd                  | R:W 2nd  | R:W NEXT                       | W:W EA                         |                                    |                            |         |                                |                                |                   |
| STC EXR.@ERd                  | R:W 2nd  | R:W NEXT                       | W:W EA                         |                                    |                            |         |                                |                                |                   |
| STC CCR.@(d:16,ERd)           | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | W:W EA                             |                            |         |                                |                                |                   |
| STC EXR.@(d:16,ERd)           | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | W:W EA                             |                            |         |                                |                                |                   |
| STC CCR.@(d:32,ERd)           | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W 5th                            | R:W NEXT                   | W:W EA  |                                |                                |                   |
| STC EXR.@(d:32,ERd)           | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W 5th                            | R:W NEXT                   | W:W EA  |                                |                                |                   |
| STC CCR.@-ERd                 | R:W 2nd  | R:W NEXT                       | Internal operation,<br>1 state | W:W EA                             |                            |         |                                |                                |                   |
| STC EXR.@-ERd                 | R:W 2nd  | R:W NEXT                       | Internal operation,<br>1 state | W:W EA                             |                            |         |                                |                                |                   |
| STC CCR.@aa:16                | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | W:W EA                             |                            |         |                                |                                |                   |
| STC EXR.@aa:16                | R:W 2nd  | R:W 3rd                        | R:W NEXT                       | W:W EA                             |                            |         |                                |                                |                   |
| STC CCR.@aa:32                | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W NEXT                           | W:W EA                     |         |                                |                                |                   |
| STC EXR.@aa:32                | R:W 2nd  | R:W 3rd                        | R:W 4th                        | R:W NEXT                           | W:W EA                     |         |                                |                                |                   |
| STM.L(ERn-ERn+1),@-SP         | R:W 2nd  | R:W NEXT                       | Internal operation,<br>1 state | W:W stack (H) <sup>3</sup>         | W:W stack (L) <sup>3</sup> |         |                                |                                |                   |
| STM.L(ERn-ERn+2),@-SP         | R:W 2nd  | R:W NEXT                       | Internal operation,<br>1 state | W:W stack (H) <sup>3</sup>         | W:W stack (L) <sup>3</sup> |         |                                |                                |                   |
| STM.L(ERn-ERn+3),@-SP         | R:W 2nd  | R:W NEXT                       | Internal operation,<br>1 state | W:W stack (H) <sup>3</sup>         | W:W stack (L) <sup>3</sup> |         |                                |                                |                   |
| STMAC MACH.ERd <sup>*11</sup> | R:W NEXT | *9                             |                                | ← Repeated n times <sup>*3</sup> → |                            |         |                                |                                |                   |
| STMAC MACL.ERd <sup>*11</sup> | R:W NEXT | *9                             |                                |                                    |                            |         |                                |                                |                   |
| SUB.B Rs.Rd                   | R:W NEXT |                                |                                |                                    |                            |         |                                |                                |                   |
| SUB.W #xx:16.Rd               | R:W 2nd  | R:W NEXT                       |                                |                                    |                            |         |                                |                                |                   |
| SUB.W Rs.Rd                   | R:W NEXT |                                |                                |                                    |                            |         |                                |                                |                   |
| SUB.L #xx:32.ERd              | R:W 2nd  | R:W 3rd                        | R:W NEXT                       |                                    |                            |         |                                |                                |                   |
| SUB.L ERs.ERd                 | R:W NEXT |                                |                                |                                    |                            |         |                                |                                |                   |
| SUBS #1/24.ERd                | R:W NEXT |                                |                                |                                    |                            |         |                                |                                |                   |
| SUBX #xx:8.Rd                 | R:W NEXT |                                |                                |                                    |                            |         |                                |                                |                   |
| SUBX Rs.Rd                    | R:W NEXT |                                |                                |                                    |                            |         |                                |                                |                   |
| TAS @ERd <sup>*10</sup>       | R:W 2nd  | R:W NEXT                       | R:B EA                         | W:B EA                             |                            |         |                                |                                |                   |
| TRAPA #x:2                    | Normal   | Internal operation,<br>1 state | W:W stack (L)                  | W:W stack (H)                      | W:W stack (EXR)            | R:W VEC | Internal operation,<br>1 state | R:W <sup>*8</sup>              |                   |
|                               | Advanced | Internal operation,<br>1 state | W:W stack (L)                  | W:W stack (H)                      | W:W stack (EXR)            | R:W VEC | R:W VEC+2                      | Internal operation,<br>1 state | R:W <sup>*8</sup> |
| XOR.B #xx:8.Rd                | R:W NEXT |                                |                                |                                    |                            |         |                                |                                |                   |

| Instruction                  | 1        | 2                           | 3                           | 4             | 5               | 6         | 7                           | 8                           | 9                          |
|------------------------------|----------|-----------------------------|-----------------------------|---------------|-----------------|-----------|-----------------------------|-----------------------------|----------------------------|
| XOR.B Rs,Rd                  | R:W NEXT |                             |                             |               |                 |           |                             |                             |                            |
| XOR.W #xx:16,Rd              | R:W 2nd  | R:W NEXT                    |                             |               |                 |           |                             |                             |                            |
| XOR.W Rs,Rd                  | R:W NEXT |                             |                             |               |                 |           |                             |                             |                            |
| XOR.L #xx:32,ERd             | R:W 2nd  | R:W 3rd                     | R:W NEXT                    |               |                 |           |                             |                             |                            |
| XOR.L ERs,ERd                | R:W 2nd  | R:W NEXT                    |                             |               |                 |           |                             |                             |                            |
| XORC #xx:8,CCR               | R:W NEXT |                             |                             |               |                 |           |                             |                             |                            |
| XORC #xx:8,EXR               | R:W 2nd  | R:W NEXT                    |                             |               |                 |           |                             |                             |                            |
| Reset exception handling     | Normal   | Internal operation, 1 state | R:W *6                      |               |                 |           |                             |                             |                            |
|                              | Advanced | R:W VEC+2                   | Internal operation, 1 state | R:W *6        |                 |           |                             |                             |                            |
| Interrupt exception handling | Normal   | Internal operation, 1 state | W:W stack (L)               | W:W stack (H) | W:W stack (EXR) | R:W VEC   | Internal operation, 1 state | Internal operation, R:W *8  |                            |
|                              | Advanced | R:W *7                      | Internal operation, 1 state | W:W stack (L) | W:W stack (H)   | R:W:W VEC | R:W VEC+2                   | Internal operation, 1 state | Internal operation, R:W *8 |

Notes: 1. EAs is the contents of ER5. EAd is the contents of ER6.

- EAs is the contents of ER5. EAd is the contents of ER6. Both registers are incremented by 1 after execution of the instruction. n is the initial value of R4L or R4. If n = 0, these bus cycles are not executed.
- Repeated two times to save or restore two registers, three times for three registers, or four times for four registers.
- For the number of states required for byte-size read or write, refer to the relevant microcontroller hardware manual.
- Start address after return.
- Start address of the program.
- Prefetch address, equal to two plus the PC value pushed onto the stack. In recovery from sleep mode or software standby mode the read operation is replaced by an internal operation.
- Start address of the interrupt-handling routine.
- An internal operation may require between 0 and 3 additional states, depending on the preceding instruction.
- Only register ER0, ER1, ER4, or ER5 should be used when using the TAS instruction.
- These instructions are supported by the H8S/2600 CPU only.

## 2.8 Condition Code Modification

This section indicates the effect of each CPU instruction on the condition code. The notation used in the table is defined below.

$$m = \begin{cases} 31 & \text{for longword operands} \\ 15 & \text{for word operands} \\ 7 & \text{for byte operands} \end{cases}$$

|    |  |
|----|--|
| Si | The i-th bit of the source operand                                   |
| Di | The i-th bit of the destination operand                              |
| Ri | The i-th bit of the result   |
| Dn | The specified bit in the destination operand                         |
| —  | Not affected   |
| ↕  | Modified according to the result of the instruction (see definition) |
| 0  | Always cleared to 0  |
| 1  | Always set to 1  |
| *  | Undetermined (no guaranteed value)                                   |
| Z' | Z flag before instruction execution                                  |
| C' | C flag before instruction execution                                  |



**Table 2.7 Condition Code Modification**

| Instruction | H | N | Z | V | C | Definition  |
|-------------|---|---|---|---|---|---|
| ADD         | ↓ | ↓ | ↓ | ↓ | ↓ | $H = Sm-4 \cdot Dm-4 + Dm-4 \cdot \overline{Rm-4} + Sm-4 \cdot \overline{Rm-4}$<br>$N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>$V = Sm \cdot Dm \cdot \overline{Rm} + \overline{Sm} \cdot \overline{Dm} \cdot Rm$<br>$C = Sm \cdot Dm + Dm \cdot \overline{Rm} + Sm \cdot \overline{Rm}$ |
| ADDS        | — | — | — | — | — |   |
| ADDX        | ↓ | ↓ | ↓ | ↓ | ↓ | $H = Sm-4 \cdot Dm-4 + Dm-4 \cdot \overline{Rm-4} + Sm-4 \cdot \overline{Rm-4}$<br>$N = Rm$<br>$Z = Z' \cdot \overline{Rm} \cdot \dots \cdot \overline{R0}$<br>$V = Sm \cdot Dm \cdot \overline{Rm} + \overline{Sm} \cdot \overline{Dm} \cdot Rm$<br>$C = Sm \cdot Dm + Dm \cdot \overline{Rm} + Sm \cdot \overline{Rm}$              |
| AND         | — | ↓ | ↓ | 0 | — | $N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$   |
| ANDC        | ↓ | ↓ | ↓ | ↓ | ↓ | Stores the corresponding bits of the result.<br>No flags change when the operand is EXR.  |
| BAND        | — | — | — | — | ↓ | $C = C' \cdot Dn$   |
| Bcc         | — | — | — | — | — |   |
| BCLR        | — | — | — | — | — |   |
| BIAND       | — | — | — | — | ↓ | $C = C' \cdot \overline{Dn}$  |
| BILD        | — | — | — | — | ↓ | $C = \overline{Dn}$   |
| BIOR        | — | — | — | — | ↓ | $C = C' + \overline{Dn}$  |
| BIST        | — | — | — | — | — |   |
| BIXOR       | — | — | — | — | ↓ | $C = C' \cdot Dn + \overline{C'} \cdot \overline{Dn}$   |
| BLD         | — | — | — | — | ↓ | $C = Dn$  |
| BNOT        | — | — | — | — | — |   |
| BOR         | — | — | — | — | ↓ | $C = C' + Dn$   |
| BSET        | — | — | — | — | — |   |
| BSR         | — | — | — | — | — |   |
| BST         | — | — | — | — | — |   |
| BTST        | — | — | ↓ | — | — | $Z = \overline{Dn}$   |
| BXOR        | — | — | — | — | ↓ | $C = C' \cdot \overline{Dn} + \overline{C'} \cdot Dn$   |
| CLRMAC*     | — | — | — | — | — |   |
| CMP         | ↓ | ↓ | ↓ | ↓ | ↓ | $H = Sm-4 \cdot \overline{Dm-4} + \overline{Dm-4} \cdot Rm-4 + Sm-4 \cdot Rm-4$<br>$N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>$V = \overline{Sm} \cdot Dm \cdot \overline{Rm} + Sm \cdot \overline{Dm} \cdot Rm$<br>$C = Sm \cdot \overline{Dm} + \overline{Dm} \cdot Rm + Sm \cdot Rm$ |

## Section 2 Instruction Descriptions

| Instruction | H | N | Z | V | C | Definition  |
|-------------|---|---|---|---|---|---|
| DAA         | * | ↕ | ↕ | * | ↕ | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>C: decimal arithmetic carry                  |
| DAS         | * | ↕ | ↕ | * | ↕ | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>C: decimal arithmetic borrow                 |
| DEC         | — | ↕ | ↕ | ↕ | — | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>V = $Dm \cdot \overline{Rm}$                 |
| DIVXS       | — | ↕ | ↕ | — | — | N = $S_m \cdot \overline{Dm} + \overline{Sm} \cdot Dm$<br>Z = $\overline{Sm} \cdot \overline{Sm-1} \cdot \dots \cdot \overline{S0}$ |
| DIVXU       | — | ↕ | ↕ | — | — | N = Sm<br>Z = $\overline{Sm} \cdot \overline{Sm-1} \cdot \dots \cdot \overline{S0}$   |
| EPMOV       | — | — | — | — | — |   |
| EXTS        | — | ↕ | ↕ | 0 | — | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$   |
| EXTU        | — | 0 | ↕ | 0 | — | Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$   |
| INC         | — | ↕ | ↕ | ↕ | — | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>V = $\overline{Dm} \cdot Rm$                 |
| JMP         | — | — | — | — | — |   |
| JSR         | — | — | — | — | — |   |
| LDC         | ↕ | ↕ | ↕ | ↕ | ↕ | Stores the corresponding bits of the result.<br>No flags change when the operand is EXR.  |
| LDM         | — | — | — | — | — |   |
| LDMAC*      | — | — | — | — | — |   |
| MAC*        | — | — | — | — | — |   |
| MOV         | — | ↕ | ↕ | 0 | — | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$   |
| MOVFP       | — | ↕ | ↕ | 0 | — | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$   |
| MOVTP       | — | ↕ | ↕ | 0 | — | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$   |
| MULXS       | — | ↕ | ↕ | — | — | N = R2m<br>Z = $\overline{R2m} \cdot \overline{R2m-1} \cdot \dots \cdot \overline{R0}$  |

| Instruction | H | N | Z | V | C | Definition  |
|-------------|---|---|---|---|---|---|
| MULXU       | — | — | — | — | — |   |
| NEG         | ↕ | ↕ | ↕ | ↕ | ↕ | $H = Dm-4 + Rm-4$<br>$N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>$V = Dm \cdot Rm$<br>$C = Dm + Rm$  |
| NOP         | — | — | — | — | — |   |
| NOT         | — | ↕ | ↕ | 0 | — | $N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$   |
| OR          | — | ↕ | ↕ | 0 | — | $N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$   |
| ORC         | ↕ | ↕ | ↕ | ↕ | ↕ | Stores the corresponding bits of the result.<br>No flags change when the operand is EXR.  |
| POP         | — | ↕ | ↕ | 0 | — | $N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$   |
| PUSH        | — | ↕ | ↕ | 0 | — | $N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$   |
| ROTL        | — | ↕ | ↕ | 0 | ↕ | $N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>$C = Dm$ (1-bit shift) or $C = Dm-1$ (2-bit shift)   |
| ROTR        | — | ↕ | ↕ | 0 | ↕ | $N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>$C = D0$ (1-bit shift) or $C = D1$ (2-bit shift)   |
| ROTXL       | — | ↕ | ↕ | 0 | ↕ | $N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>$C = Dm$ (1-bit shift) or $C = Dm-1$ (2-bit shift)   |
| ROTXR       | — | ↕ | ↕ | 0 | ↕ | $N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>$C = D0$ (1-bit shift) or $C = D1$ (2-bit shift)   |
| RTE         | ↕ | ↕ | ↕ | ↕ | ↕ | Stores the corresponding bits of the result.  |
| RTS         | — | — | — | — | — |   |
| SHAL        | — | ↕ | ↕ | ↕ | ↕ | $N = Rm$<br>$Z = \overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>$V = \overline{Dm} \cdot \overline{Dm-1} + \overline{Dm} \cdot \overline{Dm-1}$ (1-bit shift)<br>$V = \overline{Dm} \cdot \overline{Dm-1} \cdot \overline{Dm-2} + \overline{Dm} \cdot \overline{Dm-1} \cdot \overline{Dm-2}$ (2-bit shift)<br>$C = Dm$ (1-bit shift) or $C = Dm-1$ (2-bit shift) |

## Section 2 Instruction Descriptions

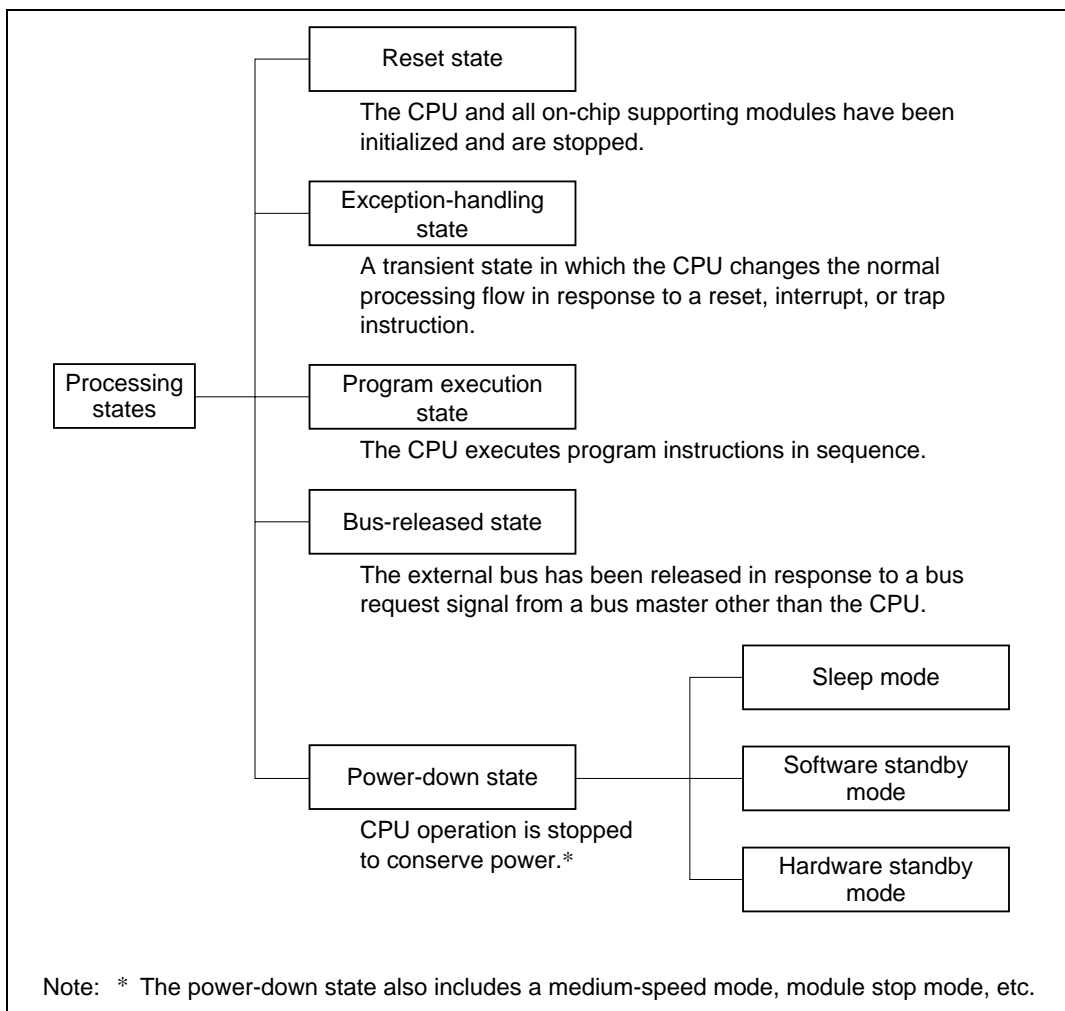
| Instruction | H | N | Z | V | C | Definition  |
|-------------|---|---|---|---|---|---|
| SHAR        | — | ↕ | ↕ | 0 | ↕ | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>C = D0 (1-bit shift) or C = D1 (2-bit shift)   |
| SHLL        | — | ↕ | ↕ | 0 | ↕ | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>C = Dm (1-bit shift) or C = Dm-1 (2-bit shift)   |
| SHLR        | — | 0 | ↕ | 0 | ↕ | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>C = D0 (1-bit shift) or C = D1 (2-bit shift)   |
| SLEEP       | — | — | — | — | — |   |
| STC         | — | — | — | — | — |   |
| STM         | — | — | — | — | — |   |
| STMAC*      | — | ↕ | ↕ | ↕ | — | N = 1 if MAC instruction resulted in negative value in MAC register<br>Z = 1 if MAC instruction resulted in zero value in MAC register<br>V = 1 if MAC instruction resulted in overflow   |
| SUB         | ↕ | ↕ | ↕ | ↕ | ↕ | H = $S_{m-4} \cdot \overline{D_{m-4}} + \overline{D_{m-4}} \cdot R_{m-4} + S_{m-4} \cdot R_{m-4}$<br>N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$<br>V = $\overline{S_m} \cdot D_m \cdot \overline{R_m} + S_m \cdot \overline{D_m} \cdot R_m$<br>C = $S_m \cdot \overline{D_m} + \overline{D_m} \cdot R_m + S_m \cdot R_m$ |
| SUBS        | — | — | — | — | — |   |
| SUBX        | ↕ | ↕ | ↕ | ↕ | ↕ | H = $S_{m-4} \cdot \overline{D_{m-4}} + \overline{D_{m-4}} \cdot R_{m-4} + S_{m-4} \cdot R_{m-4}$<br>N = Rm<br>Z = $Z' \cdot \overline{Rm} \cdot \dots \cdot \overline{R0}$<br>V = $\overline{S_m} \cdot D_m \cdot \overline{R_m} + S_m \cdot \overline{D_m} \cdot R_m$<br>C = $S_m \cdot \overline{D_m} + \overline{D_m} \cdot R_m + S_m \cdot R_m$              |
| TAS         | — | ↕ | ↕ | 0 | — | N = Dm<br>Z = $\overline{Dm} \cdot \overline{Dm-1} \cdot \dots \cdot \overline{D0}$   |
| TRAPA       | — | — | — | — | — |   |
| XOR         | — | ↕ | ↕ | 0 | — | N = Rm<br>Z = $\overline{Rm} \cdot \overline{Rm-1} \cdot \dots \cdot \overline{R0}$   |
| XORC        | ↕ | ↕ | ↕ | ↕ | ↕ | Stores the corresponding bits of the result.<br>No flags change when the operand is EXR.  |

Note: \* These instructions are supported by the H8S/2600 CPU only.

## Section 3 Processing States

### 3.1 Overview

The CPU has five main processing states: the reset state, exception handling state, program execution state, bus-released state, and power-down state. Figure 3.1 shows a diagram of the processing states. Figure 3.2 indicates the state transitions.



**Figure 3.1 Processing States**

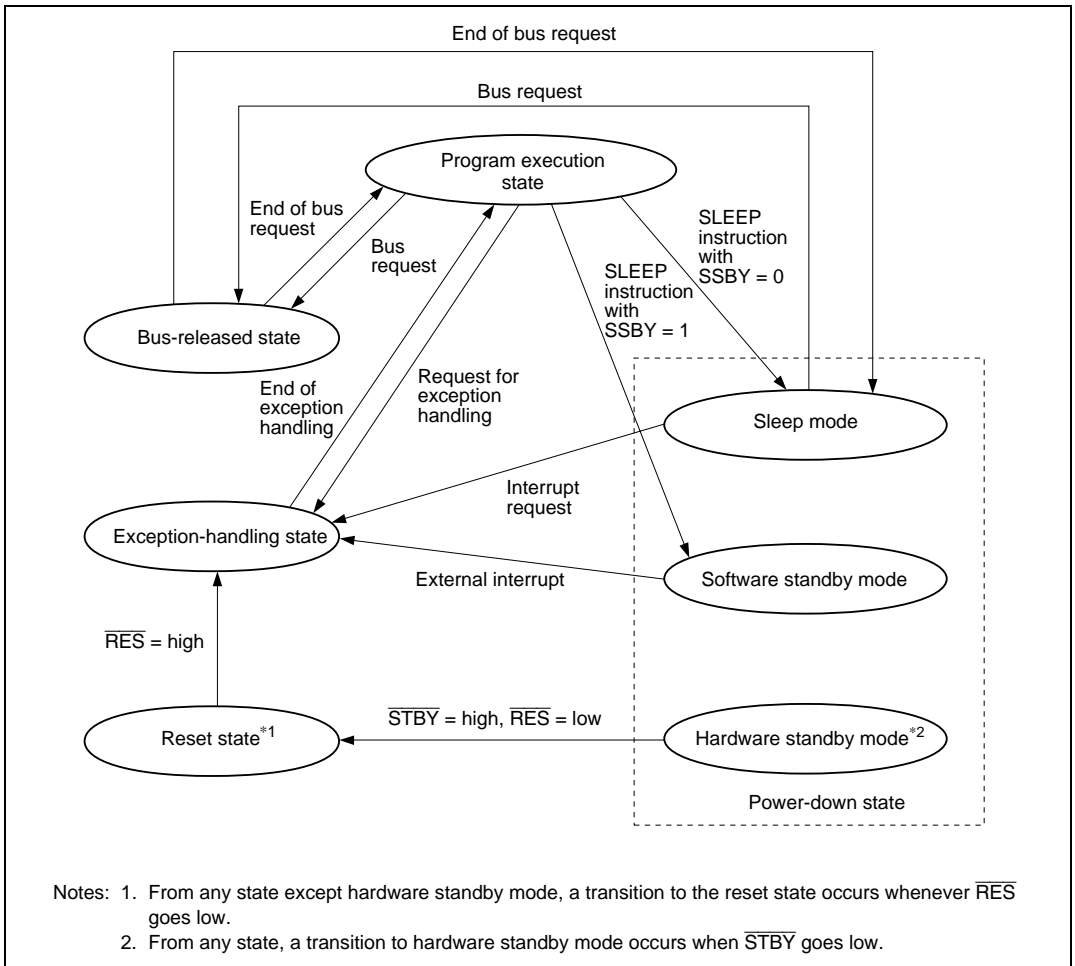


Figure 3.2 State Transitions

## 3.2 Reset State

When the  $\overline{RES}$  input goes low all current processing stops and the CPU enters the reset state. Reset exception handling starts when the  $\overline{RES}$  signal changes from low to high.

The reset state can also be entered by a watchdog timer overflow. For details, refer to the relevant microcontroller hardware manual.

### 3.3 Exception-Handling State

The exception-handling state is a transient state that occurs when the CPU alters the normal processing flow due to a reset, interrupt, or trap instruction. The CPU fetches a start address (vector) from the exception vector table and branches to that address.

#### 3.3.1 Types of Exception Handling and Their Priority

Exception handling is performed for traces, resets, interrupts, and trap instructions. Table 3.1 indicates the types of exception handling and their priority. Trap instruction exception handling is always accepted, in the program execution state.

Exception handling and the stack structure differ according to the interrupt control mode set in SYSCR.

**Table 3.1 Exception Handling Types and Priority**

| Priority | Type of Exception | Detection Timing   | Start of Exception Handling  |
|----------|-------------------|--|--|
| High     | Reset             | Synchronized with clock  | Exception handling starts immediately when $\overline{RES}$ changes from low to high   |
|          | Trace             | End of instruction execution or end of exception-handling sequence <sup>*1</sup> | When the trace (T) bit is set to 1, the trace starts at the end of the current instruction or current exception-handling sequence      |
|          | Interrupt         | End of instruction execution or end of exception-handling sequence <sup>*2</sup> | When an interrupt is requested, exception handling starts at the end of the current instruction or current exception-handling sequence |
| Low      | Trap instruction  | When TRAPA instruction is executed   | Exception handling starts when a trap (TRAPA) instruction is executed <sup>*3</sup>  |

- Notes:
1. Traces are enabled only in interrupt control modes 2 and 3. Trace exception-handling is not executed at the end of the RTE instruction.
  2. Interrupts are not detected at the end of the ANDC, ORC, XORC, and LDC instructions, or immediately after reset exception handling.
  3. Trap instruction exception handling is always accepted, in the program execution state.

For details on interrupt control modes, exception sources, and exception handling, refer to the relevant microcontroller hardware manual.

### 3.3.2 Reset Exception Handling

After the  $\overline{\text{RES}}$  pin has gone low and the reset state has been entered, reset exception handling starts when  $\overline{\text{RES}}$  goes high again. When reset exception handling starts the CPU fetches a start address (vector) from the exception vector table and starts program execution from that address. All interrupts, including NMI, are disabled during reset exception handling and after it ends.

### 3.3.3 Trace

Traces are enabled only in interrupt control modes 2 and 3. Trace mode is entered when the T bit of EXR is set to 1. When trace mode is established, trace exception handling starts at the end of each instruction.

At the end of a trace exception-handling sequence, the T bit of EXR is cleared to 0 and trace mode is cleared. Interrupt masks are not affected.

The T bit saved on the stack retains its value of 1, and when the RTE instruction is executed to return from the trace exception-handling routine, trace mode is entered again. Trace exception-handling is not executed at the end of the RTE instruction.

Trace mode is not entered in interrupt control modes 0 and 1, regardless of the state of the T bit.

### 3.3.4 Interrupt Exception Handling and Trap Instruction Exception Handling

When interrupt or trap-instruction exception handling begins, the CPU references the stack pointer (ER7) and pushes the program counter and other control registers onto the stack. Next, the CPU alters the settings of the interrupt mask bits in the control registers. Then the CPU fetches a start address (vector) from the exception vector table and execution branches to that address.

Figure 3.3 shows the stack after exception handling ends, for the case of interrupt mode 1 in advanced mode.

### 3.3.5 Usage Notes

#### (1) Conflict between Interrupt Generation and Disabling

When an interrupt enable bit is cleared to 0 to disable interrupts, the disabling becomes effective after execution of the instruction.

When an interrupt enable bit is cleared to 0 by an instruction such as BCLR or MOV, and if an interrupt is generated during execution of the instruction, the interrupt concerned will still be



enabled on completion of the instruction, and so interrupt exception handling for that interrupt will be executed on completion of the instruction. However, if there is an interrupt request of higher priority than that interrupt, interrupt exception handling will be executed for the higher-priority interrupt, and the lower-priority interrupt will be ignored. The same also applies when an interrupt source flag is cleared to 0. The above conflict will not occur if an enable bit or interrupt source flag is cleared to 0 while the interrupt is masked by the CPU.

## (2) Instructions that Disable Interrupts

The instructions that disable interrupts are LDC, ANDC, ORC, and XORC. After any of these instructions are executed, all interrupts including NMI are disabled and the next instruction is always executed. When the I bit is set by one of these instructions, the new value becomes valid two states after execution of the instruction ends.

## (3) Interrupts during Execution of EEPMOV Instructions

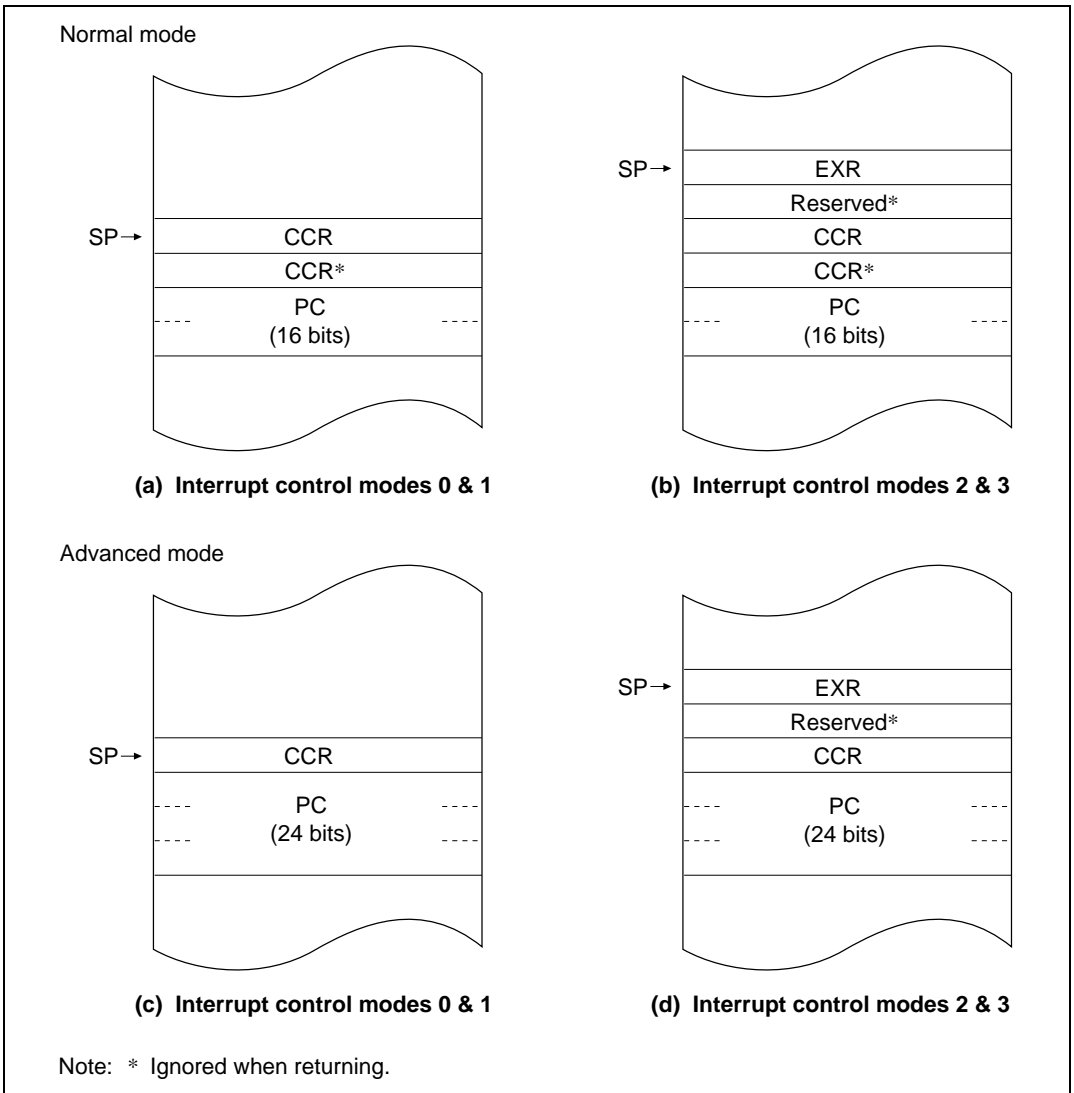
Interrupt operation differs between the EEPMOV.B instruction and the EEPMOV.W instruction.

With the EEPMOV.B instruction, an interrupt request (including NMI) issued during the transfer is not accepted until the transfer is completed.

With the EEPMOV.W instruction, if an interrupt request is issued during the transfer, interrupt exception handling starts at the next break in the transfer cycle. The PC value saved on the stack in this case is the address of the next instruction.

Therefore, if an interrupt is generated during execution of an EEPMOV.W instruction, the following coding should be used.

```
L1 :   EEPMOV.W
      MOV.W   R4, R4
      BNE    L1
```



**Figure 3.3 Stack Structure after Exception Handling (Example)**

### 3.4 Program Execution State

In this state the CPU executes program instructions in sequence.

## 3.5 Bus-Released State

This is a state in which the bus has been released in response to a bus request from a bus master other than the CPU. While the bus is released, the CPU halts except for internal operations.

Bus masters other than the CPU may include the direct memory access controller (DMAC) and data transfer controller (DTC).

For further details, refer to the relevant microcontroller hardware manual.

## 3.6 Power-Down State

The power-down state includes both modes in which the CPU stops operating and modes in which the CPU does not stop. There are three modes in which the CPU stops operating: sleep mode, software standby mode, and hardware standby mode. There are also two other power-down modes: medium-speed mode and module stop mode. In medium-speed mode the CPU and other bus masters operate on a medium-speed clock. Module stop mode permits halting of the operation of individual modules, other than the CPU. For details, refer to the relevant microcontroller hardware manual.

### 3.6.1 Sleep Mode

A transition to sleep mode is made if the SLEEP instruction is executed while the software standby bit (SSBY) in the system control register (SYSCR) is cleared to 0. In sleep mode, CPU operations stop immediately after execution of the SLEEP instruction. The contents of CPU registers are retained.

### 3.6.2 Software Standby Mode

A transition to software standby mode is made if the SLEEP instruction is executed while the SSBY bit in SYSCR is set to 1. In software standby mode, the CPU and clock halt and all on-chip operations stop. The on-chip supporting modules are reset, but as long as a specified voltage is supplied, the contents of CPU registers and on-chip RAM are retained. The I/O ports also remain in their existing states.

### 3.6.3 Hardware Standby Mode

A transition to hardware standby mode is made when the  $\overline{\text{STBY}}$  pin goes low. In hardware standby mode, the CPU and clock halt and all on-chip operations stop. The on-chip supporting modules are reset, but as long as a specified voltage is supplied, on-chip RAM contents are retained.

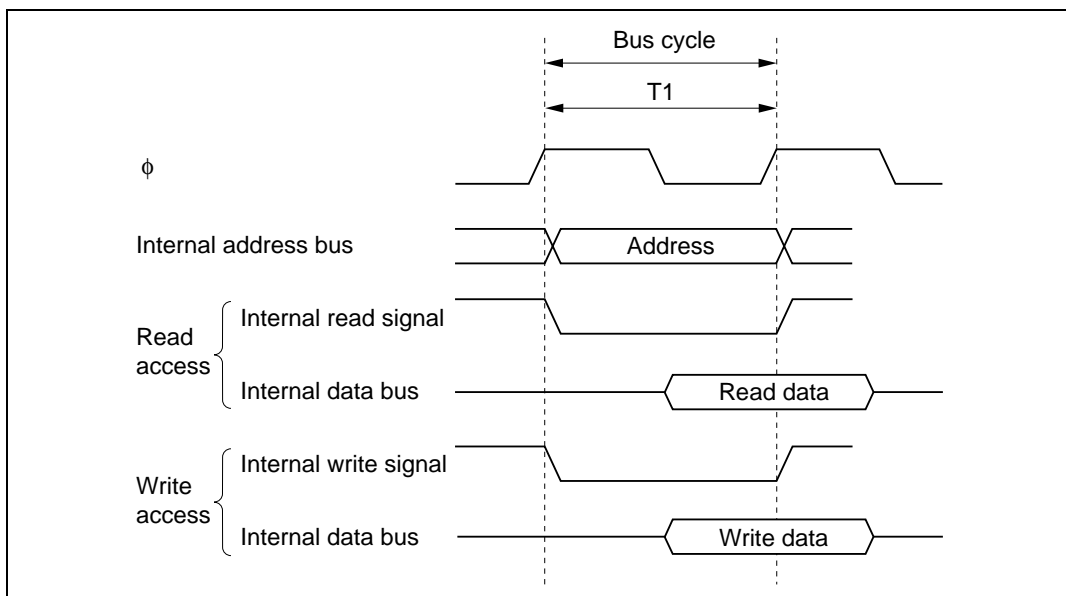
## Section 4 Basic Timing

### 4.1 Overview

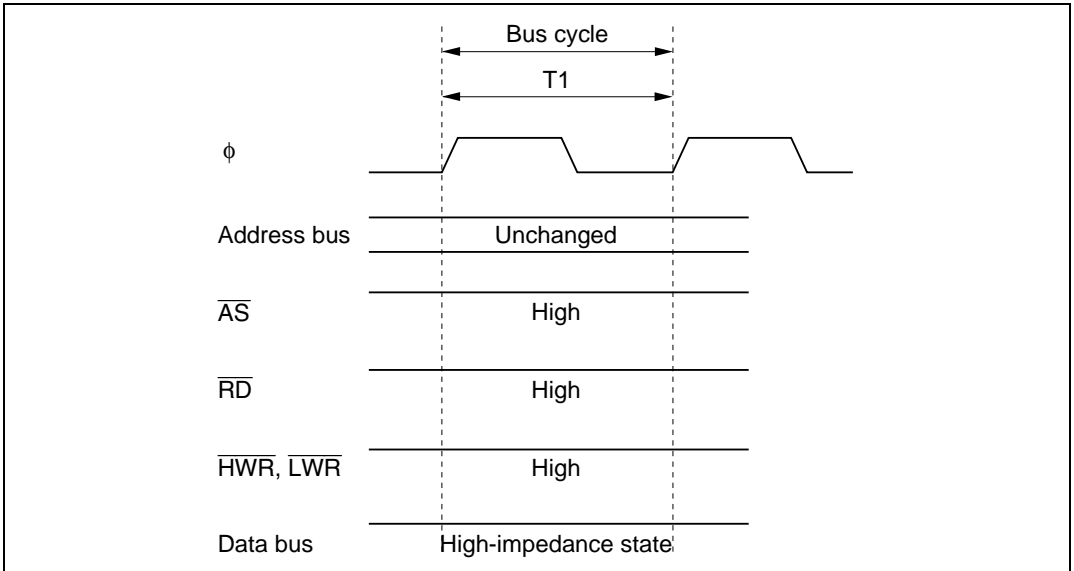
The CPU is driven by a system clock, denoted by the symbol  $\phi$ . The period from one rising edge of  $\phi$  to the next is referred to as a “state.” The memory cycle or bus cycle consists of one, two, or three states. Different methods are used to access on-chip memory, on-chip supporting modules, and the external address space. Refer to the relevant microcontroller hardware manual for details.

### 4.2 On-Chip Memory (ROM, RAM)

On-chip memory is accessed in one state. The data bus is 16 bits wide, permitting both byte and word access. Figure 4.1 shows the on-chip memory access cycle. Figure 4.2 shows the pin states.



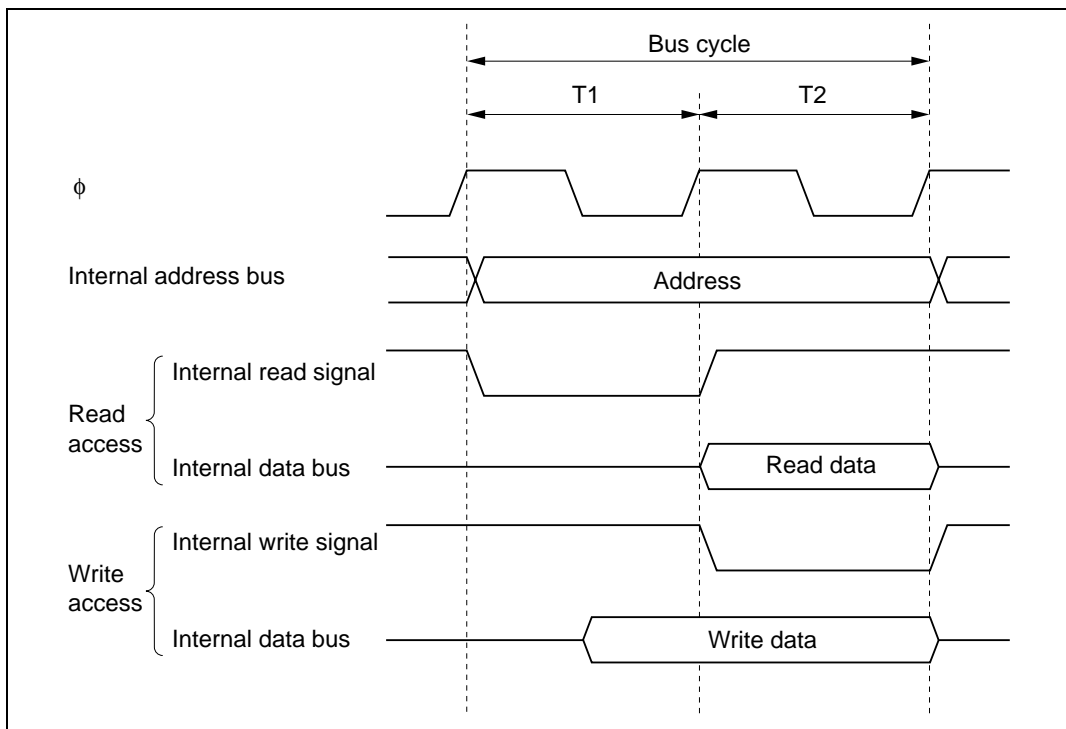
**Figure 4.1 On-Chip Memory Access Cycle**



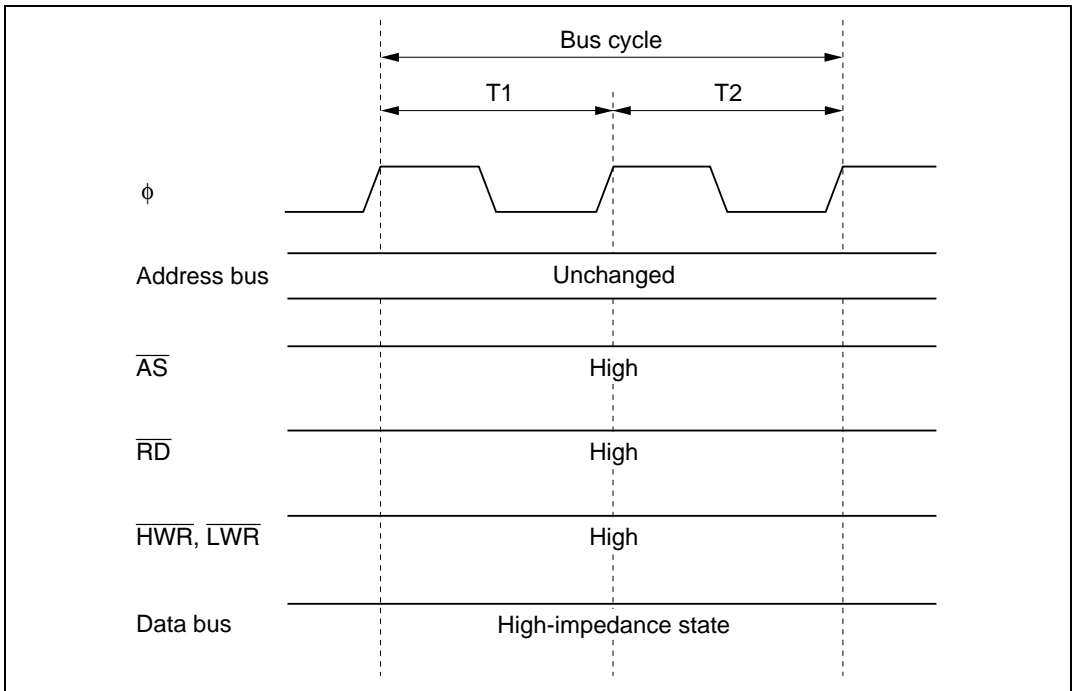
**Figure 4.2 Pin States during On-Chip Memory Access**

### 4.3 On-Chip Supporting Module Access Timing

The on-chip supporting modules are accessed in two states. The data bus is either 8 bits or 16 bits wide, depending on the particular on-chip register being accessed. Figure 4.3 shows the access timing for the on-chip supporting modules. Figure 4.4 shows the pin states.



**Figure 4.3 On-Chip Supporting Module Access Timing**

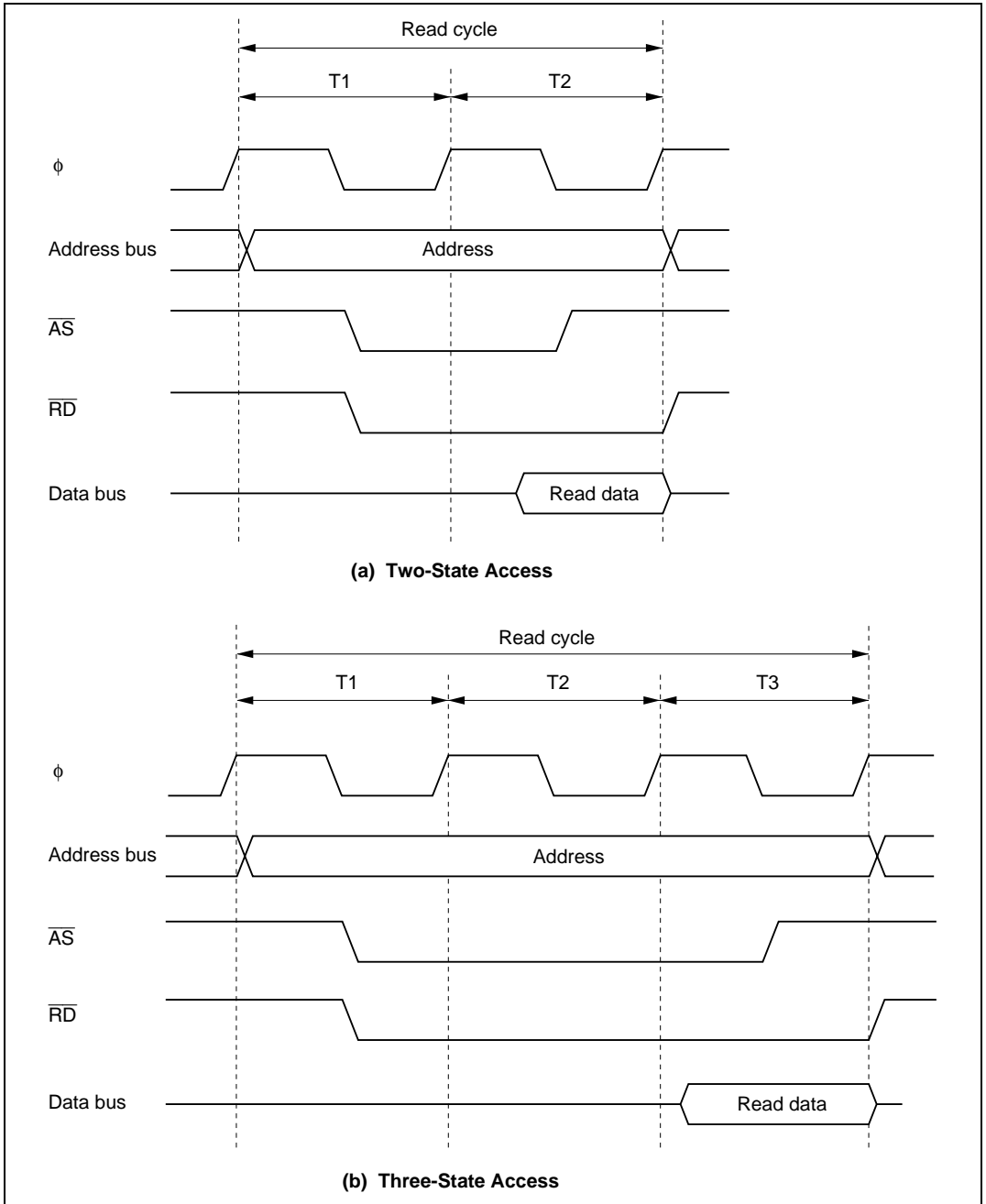


**Figure 4.4 Pin States during On-Chip Supporting Module Access**

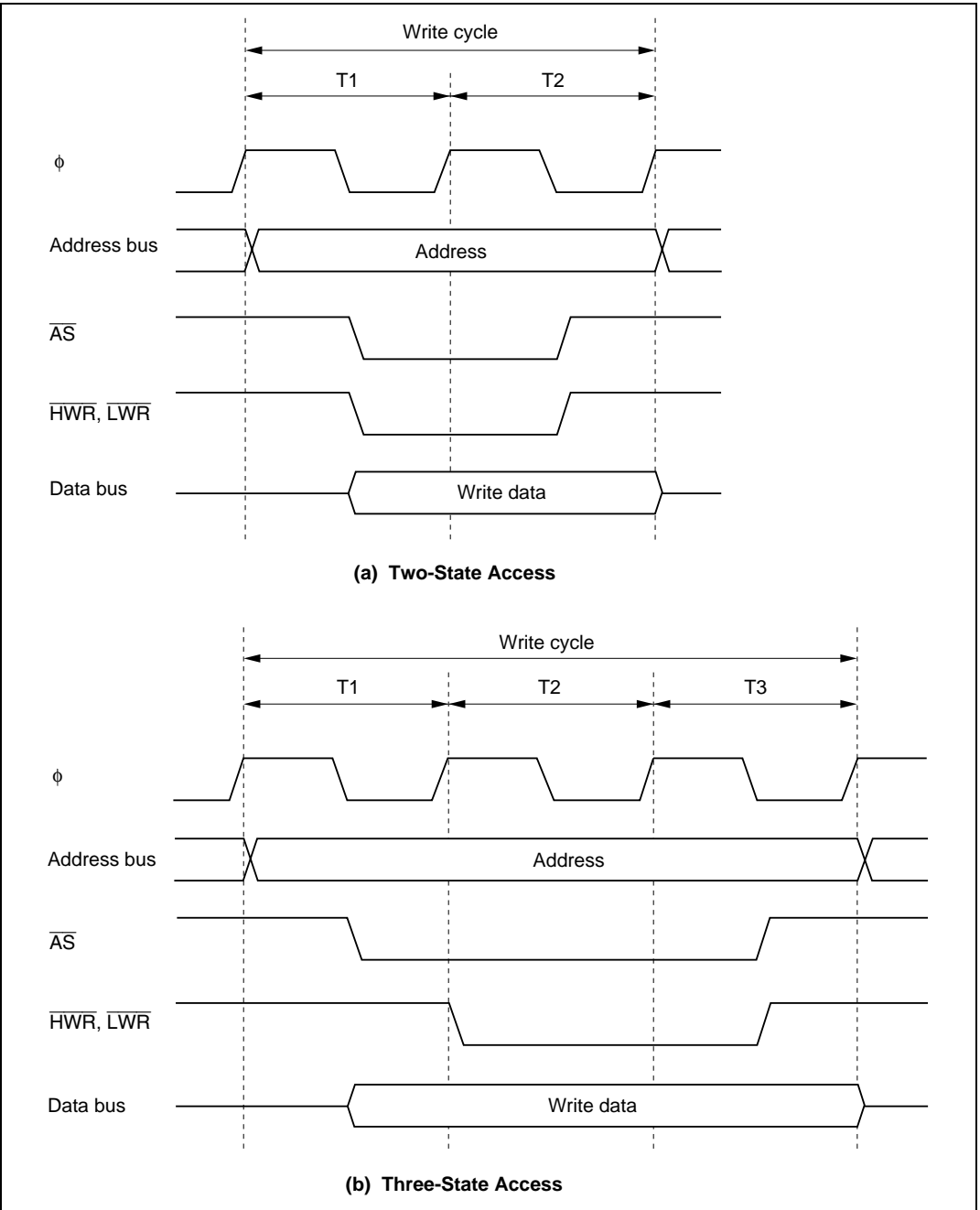
## 4.4 External Address Space Access Timing

The external address space is accessed with an 8-bit or 16-bit data bus width in a two-state or three-state bus cycle. Figure 4.5 shows the read timing for two-state and three-state access. Figure 4.6 shows the write timing for two-state and three-state access. In three-state access, wait states can be inserted. For further details, refer to the relevant microcontroller hardware manual.





**Figure 4.5 External Device Access Timing (Read Timing)**



**Figure 4.6 External Device Access Timing (Write Timing)**

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