

# Application Note

## 78K/0 Series

### 8-bit Single-chip Microcontroller

#### Basic (III)

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**$\mu$ PD78054 subseries**

**$\mu$ PD78064 subseries**

**$\mu$ PD78078 subseries**

**$\mu$ PD78083 subseries**

**$\mu$ PD780018 subseries**

**$\mu$ PD780058 subseries**

**$\mu$ PD780308 subseries**

**$\mu$ PD78058F subseries**

**$\mu$ PD78064B subseries**

**$\mu$ PD78075B subseries**

**$\mu$ PD78098B subseries**

**$\mu$ PD78054Y subseries**

**$\mu$ PD78064Y subseries**

**$\mu$ PD78078Y subseries**

**$\mu$ PD78098 subseries**

**$\mu$ PD780018Y subseries**

**$\mu$ PD780058Y subseries**

**$\mu$ PD780308Y subseries**

**$\mu$ PD78058FY subseries**

**$\mu$ PD78070A, 78070AY**

**$\mu$ PD78075BY subseries**

[MEMO]

## NOTES FOR CMOS DEVICES

### ① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS

Note:

Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

### ② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note:

No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to  $V_{DD}$  or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

### ③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note:

Power-on does not necessarily define initial status of MOS device. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the devices with reset function have not yet been initialized. Hence, power-on does not guarantee out-pin levels, I/O settings or contents of registers. Device is not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for devices having reset function.

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While NEC Corporation has been making continuous effort to enhance the reliability of its semiconductor devices, the possibility of defects cannot be eliminated entirely. To minimize risks of damage or injury to persons or property arising from a defect in an NEC semiconductor device, customers must incorporate sufficient safety measures in its design, such as redundancy, fire-containment, and anti-failure features.

NEC devices are classified into the following three quality grades:

"Standard", "Special", and "Specific". The Specific quality grade applies only to devices developed based on a customer designated "quality assurance program" for a specific application. The recommended applications of a device depend on its quality grade, as indicated below. Customers must check the quality grade of each device before using it in a particular application.

Standard: Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots

Special: Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support)

Specific: Aircrafts, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems or medical equipment for life support, etc.

The quality grade of NEC devices is "Standard" unless otherwise specified in NEC's Data Sheets or Data Books. If customers intend to use NEC devices for applications other than those specified for Standard quality grade, they should contact an NEC sales representative in advance.

Anti-radioactive design is not implemented in this product.

# Regional Information

Some information contained in this document may vary from country to country. Before using any NEC product in your application, please contact the NEC office in your country to obtain a list of authorized representatives and distributors. They will verify:

- Device availability
- Ordering information
- Product release schedule
- Availability of related technical literature
- Development environment specifications (for example, specifications for third-party tools and components, host computers, power plugs, AC supply voltages, and so forth)
- Network requirements

In addition, trademarks, registered trademarks, export restrictions, and other legal issues may also vary from country to country.

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## Major Revisions in This Edition

| Page  | Description  |
|---|--|
| Throughout                                  | <p>Addition of following products as target products:<br/> <math>\mu</math>PD780018, 780018Y, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY, 78098B subseries, <math>\mu</math>PD78070A, 78070AY<br/> <math>\mu</math>PD78052(A), 78053(A), 78054(A)<br/> <math>\mu</math>PD78062(A), 78063(A), 78064(A)<br/> <math>\mu</math>PD78081(A), 78082(A), 78P083(A), 78081(A2)<br/> <math>\mu</math>PD78058F(A), 78058FY(A)<br/> <math>\mu</math>PD78064B(A)</p> <p>Deletion of following products as target products:<br/> <math>\mu</math>PD78P054Y, 78P064Y, 78074, 78075, 78075, 78074Y, 78075Y</p> |
| p.100                                       | Addition of <b>Note 2</b> and <b>Caution 2</b> to <b>Figure 4-5 Format of Watchdog Timer Mode Register</b>   |
| p.113                                       | Addition of Caution to <b>Figure 5-8 Format of External Interrupt Mode Register 0</b>  |
| p.196                                       | Addition of <b>Table 8-2 Items Supported by Each Subseries</b>   |
| p.197                                       | Addition of <b>Table 8-3 Registers of Serial Interface</b>   |
| p.204, p.206                                | Addition of note on using wake-up function and note on changing operation mode to <b>Figures 8-7 and 8-8 Format of Serial Operating Mode Register 0</b>  |
| p.218, p.224                                | Addition of Caution to <b>Figures 8-16 and 8-17 Format of Automatic Data Transfer/Reception Interval Specification Register</b>  |
| p.239                                       | Addition of <b>Figures 8-23 and 8-24 Format of Serial Interface Pin Select Register</b>  |
| p.240                                       | $\mu$ PD6252 as maintenance product in <b>8.1 Interface with EEPROM™ (<math>\mu</math>PD6252)</b>  |
| p.250                                       | Addition of <b>(5) Limitations when using I<sup>2</sup>C bus mode</b> to <b>8.1.2 Communication in I<sup>2</sup>C bus mode</b>   |
| p.286                                       | Addition of <b>(f) Limitations when using UART mode</b> to <b>8.5 Interface in Asynchronous Serial Interface (UART) Mode</b>   |
| p.347                                       | Addition of <b>Figure 11-3 Format of Port Mode Register 12</b>   |
| p.216, p.217<br>p.229-p.232<br>p.352, p.353 | <p>Description of following register formats and tables for each subseries:<br/>           Figures 8-14 and 8-15 Format of Automatic Data Transmission/Reception Control Register<br/>           Tables 8-4, 8-5, and 8-6 Setting of Operation Modes of Serial Interface Channel 2<br/>           Figures 12-1 and 12-2 Format of LCD Display Mode Register</p>  |
| p.387                                       | Addition of <b>APPENDIX B REVISION HISTORY</b>   |

The mark ★ shows major revised points.

## INTRODUCTION

### Readers

This Application Note is intended for use by engineers who understand the functions of the 78K/0 series and wish to design application programs with the following subseries products:

#### • Subseries

- $\mu$ PD78054 subseries :  $\mu$ PD78052, 78053, 78054, 78P054, 78055, 78056, 78058, 78P058, 78052(A), 78053(A), 78054(A)
- $\mu$ PD78054Y subseries :  $\mu$ PD78052Y, 78053Y, 78054Y, 78055Y, 78056Y, 78058Y, 78P058Y
- $\mu$ PD78064 subseries :  $\mu$ PD78062, 78063, 78064, 78P064, 78062(A), 78063(A), 78064(A)
- $\mu$ PD78064Y subseries :  $\mu$ PD78062Y, 78063Y, 78064Y
- $\mu$ PD78078 subseries :  $\mu$ PD78076, 78078, 78P078
- $\mu$ PD78078Y subseries :  $\mu$ PD78076Y, 78078Y, 78P078Y
- $\mu$ PD78083 subseries :  $\mu$ PD78081, 78082, 78P083, 78081(A), 78082(A), 78P83(A), 78081(A2)
- $\mu$ PD78098 subseries :  $\mu$ PD78094, 78095, 78096, 78098A<sup>Note 1</sup>, 78P098A<sup>Note 1</sup>
- $\mu$ PD780018 subseries :  $\mu$ PD780016<sup>Note 2</sup>, 780018<sup>Note 2</sup>, 78P0018<sup>Note 2</sup>
- $\mu$ PD780018Y subseries :  $\mu$ PD780016Y<sup>Note 2</sup>, 780018Y<sup>Note 2</sup>, 78P0018Y<sup>Note 2</sup>
- $\mu$ PD780058 subseries :  $\mu$ PD780053<sup>Note 1</sup>, 780054<sup>Note 1</sup>, 780055<sup>Note 1</sup>, 780056<sup>Note 1</sup>, 780058<sup>Note 1</sup>, 78F0058<sup>Note 1</sup>
- $\mu$ PD780058Y subseries :  $\mu$ PD780053Y<sup>Note 2</sup>, 780054Y<sup>Note 2</sup>, 780055Y<sup>Note 2</sup>, 780056Y<sup>Note 2</sup>, 780058Y<sup>Note 2</sup>, 78F0058Y<sup>Note 2</sup>
- $\mu$ PD780308 subseries :  $\mu$ PD780306<sup>Note 1</sup>, 780308<sup>Note 1</sup>, 78P0308<sup>Note 1</sup>
- $\mu$ PD780308Y subseries :  $\mu$ PD780306Y<sup>Note 1</sup>, 780308Y<sup>Note 1</sup>, 78P0308Y<sup>Note 1</sup>
- $\mu$ PD78058F subseries :  $\mu$ PD78056F, 78058F, 78P058F, 78058F(A)
- $\mu$ PD78058FY subseries :  $\mu$ PD78056FY, 78058FY, 78P058FY, 78P058FY(A)
- $\mu$ PD78064B subseries :  $\mu$ PD78064B, 78P064B, 78064B(A)
- $\mu$ PD78070A, 78070AY
- $\mu$ PD78075B subseries :  $\mu$ PD78074B, 78075B
- $\mu$ PD78075BY subseries :  $\mu$ PD78074BY<sup>Note 1</sup>, 78075BY<sup>Note 1</sup>
- $\mu$ PD78098B subseries :  $\mu$ PD78095B<sup>Note 2</sup>, 78096B<sup>Note 2</sup>, 78098B<sup>Note 2</sup>, 78P098B<sup>Note 2</sup>

- Notes**
1. Under development
  2. Planned

- Remarks**
1. The  $\mu$ PD78052(A), 78053(A), and 78054(A) have higher reliability than the  $\mu$ PD78052, 78053, and 78054.
  2. The  $\mu$ PD78062(A), 78063(A), and 78064(A) have higher reliability than the  $\mu$ PD78062, 78063, and 78064.
  3. The  $\mu$ PD78081(A), 78082(A), 78P083(A), and 78081(A2) have higher reliability than the  $\mu$ PD78081, 78082, and 78P083.
  4. The  $\mu$ PD78058F(A) and 78058FY(A) have higher reliability than the  $\mu$ PD78058F and 78058FY.
  5. The  $\mu$ PD78064B(A) has higher reliability than the  $\mu$ PD78064B.

**Purpose**

This Application Note is to deepen your understanding of the basic functions of the 78K/0 series by using program examples.

Note that the programs and hardware configuration shown in this document are only examples and not subject to mass production.

**Organization**

This Application Note consists of the following contents:

- General
- Software
- Hardware

In addition to this Application Note, the following Application Notes are also available:

| Document Name   | Document Number |               | Targeted Subseries  | Contents  |
|---|-----------------|---------------|---|---|
|   | Japanese        | English       |   |   |
| 78K/0 Series<br>Application Note<br>Basic (I)                           | IEA-715         | IEA-1288      | $\mu$ PD78002, 78002Y<br>$\mu$ PD78014, 78014Y<br>$\mu$ PD78018F, 78018FY   | Explains basic functions of products in 78K/0 series by using program examples  |
| 78K/0 Series<br>Application Note<br>Basic (II)                          | U10121J         | U10121E       | $\mu$ PD78044<br>$\mu$ PD78044H<br>$\mu$ PD780208<br>$\mu$ PD780228   |   |
| 78K/0 Series<br>Application Note<br>Basic (III)                         | U10182J         | This document | $\mu$ PD78054, 78054Y<br>$\mu$ PD78064, 78064Y<br>$\mu$ PD78078, 78078Y<br>$\mu$ PD78083<br>$\mu$ PD78098<br>$\mu$ PD780018, 780018Y<br>$\mu$ PD780058, 780058Y<br>$\mu$ PD780308, 780308Y<br>$\mu$ PD78058F, 78058FY<br>$\mu$ PD78064B<br>$\mu$ PD78070A, 78070AY<br>$\mu$ PD78075B, 78075BY<br>$\mu$ PD78098B |   |
| 78K/0 Series<br>Application Note<br>Floating-Point<br>Operation Program | IEA-718         | IEA-1289      | All subseries in 78K/0 series<br>(except $\mu$ PD78002 and<br>78002Y subseries)   | Explains floating-point operation programs of products in 78K/0 series          |
| $\mu$ PD78014 Series<br>Application Note<br>Electronic Pocketbook       | IEA-744         | IEA-1301      | $\mu$ PD78014<br>(only $\mu$ PD78014 and<br>78P014)   | Explains how to organize electronic pocketbook by using $\mu$ PD78014 subseries |

**Caution** The application examples and program lists shown in this Application Note assume that the main system clock operates at 4.19 MHz, not at 5.0 MHz.



## How to Read This Manual

Although this Application Note explains the functions of the 78K/0 series products, the functions of some products in each subseries differ from those of the others.

(1/2)

| Chapter  | Subseries | $\mu$ PD78054  | $\mu$ PD78064  | $\mu$ PD78078  | $\mu$ PD78083 | $\mu$ PD78098 | $\mu$ PD780018  | $\mu$ PD780058  |
|--|-----------|----------------|----------------|----------------|---------------|---------------|-----------------|-----------------|
|  |           | $\mu$ PD78054Y | $\mu$ PD78064Y | $\mu$ PD78078Y |               |               | $\mu$ PD780018Y | $\mu$ PD780058Y |
| CHAPTER 1 GENERAL                                    |           | ○              | ○              | ○              | ○             | ○             | ○               | ○               |
| CHAPTER 2 FUNDAMENTALS OF SOFTWARE                   |           | ○              | ○              | ○              | ○             | ○             | ○               | ○               |
| CHAPTER 3 APPLICATIONS OF SYSTEM CLOCK SELECTION     |           | ○              | ○              | ○              | ○             | ○             | ○               | ○               |
| CHAPTER 4 APPLICATIONS OF WATCHDOG TIMER             |           | ○              | ○              | ○              | ○             | ○             | ○               | ○               |
| CHAPTER 5 APPLICATIONS OF 16-BIT TIMER/EVENT COUNTER |           | ○              | ○              | ○              | -             | ○             | ○               | ○               |
| CHAPTER 6 APPLICATIONS OF 8-BIT TIMER/EVENT COUNTER  |           | ○              | ○              | ○              | -             | ○             | ○               | ○               |
| CHAPTER 7 APPLICATIONS OF WATCH TIMER                |           | ○              | ○              | ○              | -             | ○             | ○               | ○               |
| CHAPTER 8 APPLICATIONS OF SERIAL INTERFACE           |           | ○              | ○              | ○              | ○             | ○             | ○               | ○               |
| CHAPTER 9 APPLICATIONS OF A/D CONVERTER              |           | ○              | ○              | ○              | ○             | ○             | ○               | ○               |
| CHAPTER 10 APPLICATIONS OF D/A CONVERTER             |           | ○              | -              | ○              | -             | ○             | -               | ○               |
| CHAPTER 11 APPLICATION OF REAL-TIME OUTPUT PORT      |           | ○              | -              | ○              | -             | ○             | -               | ○               |
| CHAPTER 12 APPLICATIONS OF LCD CONTROLLER/DRIVER     |           | -              | ○              | -              | -             | -             | -               | -               |
| CHAPTER 13 APPLICATIONS OF KEY INPUT                 |           | ○              | ○              | ○              | -             | ○             | ○               | ○               |

(2/2)

| Chapter  | Subseries | $\mu$ PD780308  | $\mu$ PD78058F  | $\mu$ PD78064B | $\mu$ PD78070A  | $\mu$ PD78075B  | $\mu$ PD78098B |
|--|-----------|-----------------|-----------------|----------------|-----------------|-----------------|----------------|
|  |           | $\mu$ PD780308Y | $\mu$ PD78058FY |                | $\mu$ PD78070AY | $\mu$ PD78075BY |                |
| CHAPTER 1 GENERAL                                    |           | ○               | ○               | ○              | ○               | ○               | ○              |
| CHAPTER 2 FUNDAMENTALS OF SOFTWARE                   |           | ○               | ○               | ○              | ○               | ○               | ○              |
| CHAPTER 3 APPLICATIONS OF SYSTEM CLOCK SELECTION     |           | ○               | ○               | ○              | ○               | ○               | ○              |
| CHAPTER 4 APPLICATIONS OF WATCHDOG TIMER             |           | ○               | ○               | ○              | ○               | ○               | ○              |
| CHAPTER 5 APPLICATIONS OF 16-BIT TIMER/EVENT COUNTER |           | ○               | ○               | ○              | ○               | ○               | ○              |
| CHAPTER 6 APPLICATIONS OF 8-BIT TIMER/EVENT COUNTER  |           | ○               | ○               | ○              | ○               | ○               | ○              |
| CHAPTER 7 APPLICATIONS OF WATCH TIMER                |           | ○               | ○               | ○              | ○               | ○               | ○              |
| CHAPTER 8 APPLICATIONS OF SERIAL INTERFACE           |           | ○               | ○               | ○              | ○               | ○               | ○              |
| CHAPTER 9 APPLICATIONS OF A/D CONVERTER              |           | ○               | ○               | ○              | ○               | ○               | ○              |
| CHAPTER 10 APPLICATIONS OF D/A CONVERTER             |           | -               | ○               | -              | ○               | ○               | ○              |
| CHAPTER 11 APPLICATION OF REAL-TIME OUTPUT PORT      |           | -               | ○               | -              | ○               | ○               | ○              |
| CHAPTER 12 APPLICATIONS OF LCD CONTROLLER/DRIVER     |           | ○               | -               | ○              | -               | -               | -              |
| CHAPTER 13 APPLICATIONS OF KEY INPUT                 |           | ○               | ○               | ○              | ○               | ○               | ○              |

The (A)-model and standard models differ only in quality grade.

The  $\mu$ PD78081(A2) differs from standard models and (A)-models in terms of supply voltage and operating temperature range. For details, refer to the individual Data Sheet.

In this document, read (A)-models and (A2)-model as follows:

|                |   |                   |                 |   |                    |
|----------------|---|-------------------|-----------------|---|--------------------|
| $\mu$ PD78052  | → | $\mu$ PD78052(A)  | $\mu$ PD78053   | → | $\mu$ PD78053(A)   |
| $\mu$ PD78054  | → | $\mu$ PD78054(A)  | $\mu$ PD78062   | → | $\mu$ PD78062(A)   |
| $\mu$ PD78063  | → | $\mu$ PD78063(A)  | $\mu$ PD78064   | → | $\mu$ PD78064(A)   |
| $\mu$ PD78081  | → | $\mu$ PD78081(A)  | $\mu$ PD78082   | → | $\mu$ PD78082(A)   |
| $\mu$ PD78P083 | → | $\mu$ PD78P083(A) | $\mu$ PD78081   | → | $\mu$ PD78081(A2)  |
| $\mu$ PD78058F | → | $\mu$ PD78058F(A) | $\mu$ PD78058FY | → | $\mu$ PD78058FY(A) |
| $\mu$ PD78064B | → | $\mu$ PD78064B(A) |                 |   |                    |

## Legend

Data significance : Left: higher digit, right: lower digit  
Low active :  $\overline{\text{xxx}}$  (top bar over pin or signal name)  
**Note** : Description of **Note** in the text  
**Caution** : Important information  
**Remark** : Supplement  
Numeric representation : Binary ...  $\text{xxxx}$  or  $\text{xxxxB}$   
Decimal ...  $\text{xxxx}$   
Hexadecimal ...  $\text{xxxxH}$

## Quality Grade

### • Standard

$\mu$ PD78052, 78053, 78054, 78055, 78056, 78058, 78P058  
 $\mu$ PD78052Y, 78053Y, 78054Y, 78055Y, 78056Y, 78058Y, 78P058Y  
 $\mu$ PD78062, 78063, 78064, 78P064  
 $\mu$ PD78062Y, 78063Y, 78064Y  
 $\mu$ PD78076, 78078, 78P078  
 $\mu$ PD78076Y, 78078Y, 78P078Y  
 $\mu$ PD78081, 78082, 78P083  
 $\mu$ PD78094, 78095, 78096, 78098A, 78P098A  
 $\mu$ PD780016, 780018, 78P0018  
 $\mu$ PD780016Y, 780018Y, 78P0018Y  
 $\mu$ PD780053, 780054, 780055, 780056, 780058, 78F0058  
 $\mu$ PD780053Y, 780054Y, 780055Y, 780056Y, 780058Y, 78F0058Y  
 $\mu$ PD780306, 780308, 78P0308  
 $\mu$ PD780306Y, 780308Y, 78P0308Y  
 $\mu$ PD78056F, 78058F, 78P058F  
 $\mu$ PD78056FY, 78058FY, 78P058FY  
 $\mu$ PD78064B, 78P064B  
 $\mu$ PD78070A, 78070AY  
 $\mu$ PD78074B, 78075B  
 $\mu$ PD78074BY, 78075BY  
 $\mu$ PD78095B, 78096B, 78098B, 78P098B

- **Special**

μPD78052(A), 78053(A), 78054(A)

μPD78062(A), 78063(A), 78064(A)

μPD78082(A), 78083(A), 78P083(A), 78081(A2)

μPD78058F(A), 78058FY(A)

μPD78064B(A)

Please refer to "Quality Grades on NEC Semiconductor Devices" (Document No. C11531E) published by NEC Corporation to know the specification of quality grade on the devices and its recommended applications.

**Application Field**

- Consumer appliances

**Related documents**

Some of the related documents listed below are preliminary versions but not so specified here.

- **Common related documents**

| Document Name  | Document Number |               |
|--|-----------------|---------------|
|  | Japanese        | English       |
| 78K/0 Series Application Note - Basic (III)                      | U10182J         | This document |
| 78K/0 Series Application Note - Floating-Point Operation Program | IEA-718         | IEA-1289      |
| 78K/0 Series User's Manual - Instruction                         | U12326J         | U12326E       |
| 78K/0 Series Instruction Set                                     | U10904J         | —             |
| 78K/0 Series Instruction Table                                   | U10903J         | —             |

- Documents dedicated to product

**(1)  $\mu$ PD78054 subseries**

| Document Name   | Document Number |         |
|---|-----------------|---------|
|   | Japanese        | English |
| $\mu$ PD78052, 78053, 78054, 78055, 78056, 78058 Data Sheet | U12327J         | IC-3403 |
| $\mu$ PD78P054 Data Sheet                                   | U12346J         | U12346E |
| $\mu$ PD78P058 Data Sheet                                   | IC-8884         | U10417E |
| $\mu$ PD78054, $\mu$ PD78054Y Subseries User's Manual       | U11747J         | U11747E |
| $\mu$ PD78054 Subseries Special Function Register Table     | U10102J         | –       |
| $\mu$ PD78052(A), 78053(A), 78054(A) Data Sheet             | U12171J         | U12171E |

**(2)  $\mu$ PD78054Y subseries**

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|   | Japanese        | English |
| $\mu$ PD78052Y, 78053Y, 78054Y, 78056Y, 78058Y Data Sheet | U10906J         | U10906E |
| $\mu$ PD78P058Y Data Sheet                                | U10907J         | U10907E |
| $\mu$ PD78054, 78054Y Subseries User's Manual             | U11747J         | U11747E |
| $\mu$ PD78054Y Subseries Special Function Register Table  | U10087J         | –       |

**(3)  $\mu$ PD78064 subseries**

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|   | Japanese        | English |
| $\mu$ PD78062, 78063, 78064 Data Sheet                  | U12238J         | U12338E |
| $\mu$ PD78P064 Data Sheet                               | U12589J         | U12589E |
| $\mu$ PD78062(A), 78063(A), 78064(A) Data Sheet         | U10335J         | U10335E |
| $\mu$ PD78064, 78064Y Subseries User's Manual           | U10105J         | U10105E |
| $\mu$ PD78064 Subseries Special Function Register Table | IEM-5568        | –       |

**(4)  $\mu$ PD78064Y subseries**

| Document Name  | Document Number |         |
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**(6)  $\mu$ PD78078Y subseries**

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**(7)  $\mu$ PD78083 subseries**

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| $\mu$ PD78P083 Data Sheet                               | U11006J         | U11006E             |
| uPD78081(A), 78082(A) Data Sheet                        | U12436J         | To be released soon |
| uPD78P083(A) Data Sheet                                 | U12175J         | U12175E             |
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**(8)  $\mu$ PD78098 subseries**

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| $\mu$ PD78P098A Data Sheet                             | U10203J         | U10203E  |
| $\mu$ PD78098 Subseries User's Manual                  | IEU-854         | IEU-1381 |
| $\mu$ PD78098 Subseries Special Function Register List | IEM-5591        | –        |

**(9)  $\mu$ PD780018 subseries**

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|--|-----------------|-----------------|
|  | Japanese        | English         |
| $\mu$ PD780016, 780018 Preliminary Product Information | Plan to prepare | Plan to prepare |
| $\mu$ PD78P0018 Preliminary Product Information        | Plan to prepare | Plan to prepare |
| $\mu$ PD780018, 780018Y Subseries User's Manual        | Plan to prepare | Plan to prepare |

**(10)  $\mu$ PD780018Y subseries**

| Document Name  | Document Number |                 |
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| $\mu$ PD78P0018Y Preliminary Product Information         | Plan to prepare | Plan to prepare |
| $\mu$ PD780018, 780018Y Subseries User's Manual          | Plan to prepare | Plan to prepare |

**(11)  $\mu$ PD780058 subseries**

| Document Name  | Document Number |         |
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|  | Japanese        | English |
| $\mu$ PD780053, 780054, 780055, 780056, 780058 Preliminary Product Information | U12182J         | U12182E |
| $\mu$ PD78F0058 Preliminary Product Information                                | U12092J         | U12092E |
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**(12)  $\mu$ PD780058, 780058Y subseries**

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**(13)  $\mu$ PD780308 subseries**

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| $\mu$ PD780308, 780308Y Subseries User's Manual | U11377J         | U11377E |

**(14)  $\mu$ PD780308Y subseries**

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**(15)  $\mu$ PD78058F subseries**

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| $\mu$ PD78P058F Data Sheet                      | U11796J             | U11796E         |
| $\mu$ PD78058F(A) Data Sheet                    | To be released soon | Plan to prepare |
| $\mu$ PD78058F, 78058FY Subseries User's Manual | U12068J             | U12068E         |

**(16)  $\mu$ PD78058FY subseries**

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| $\mu$ PD78P058FY Data Sheet                     | U12076J         | U12076E             |
| $\mu$ PD78058F, 78058FY Subseries User's Manual | U12068J         | To be released soon |

**(17)  $\mu$ PD78064B subseries**

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| $\mu$ PD78064B Data Sheet             | U11590J         | U11590E |
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| $\mu$ PD780308, 780308Y User's Manual | U10785J         | U10785E |

**(18)  $\mu$ PD78070A, 78070AY subseries**

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| $\mu$ PD78070A Data Sheet             | U10326J         | U10326E |
| $\mu$ PD78070AY Data Sheet            | U10542J         | U10542E |
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**(19)  $\mu$ PD78075B subseries**

| Document Name                                   | Document Number |                     |
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|   | Japanese        | English             |
| $\mu$ PD78074B, 78075B Data Sheet               | U12017J         | U12017E             |
| $\mu$ PD78075B, 78075BY Subseries User's Manual | U12560J         | To be released soon |

**(20)  $\mu$ PD78075BY subseries**

| Document Name                                   | Document Number |                     |
|---|-----------------|---------------------|
|   | Japanese        | English             |
| $\mu$ PD78074BY, 78075BY Data Sheet             | Plan to prepare | Plan to prepare     |
| $\mu$ PD78075B, 78075BY Subseries User's Manual | U12560J         | To be released soon |

**(21)  $\mu$ PD78098B subseries**

| Document Name                             | Document Number     |                 |
|---|---------------------|-----------------|
|   | Japanese            | English         |
| $\mu$ PD78095B, 78096B, 78098B Data Sheet | Plan to prepare     | Plan to prepare |
| $\mu$ PD78P098B Data Sheet                | Plan to prepare     | Plan to prepare |
| $\mu$ PD78098B Subseries User's Manual    | To be released soon | Plan to prepare |

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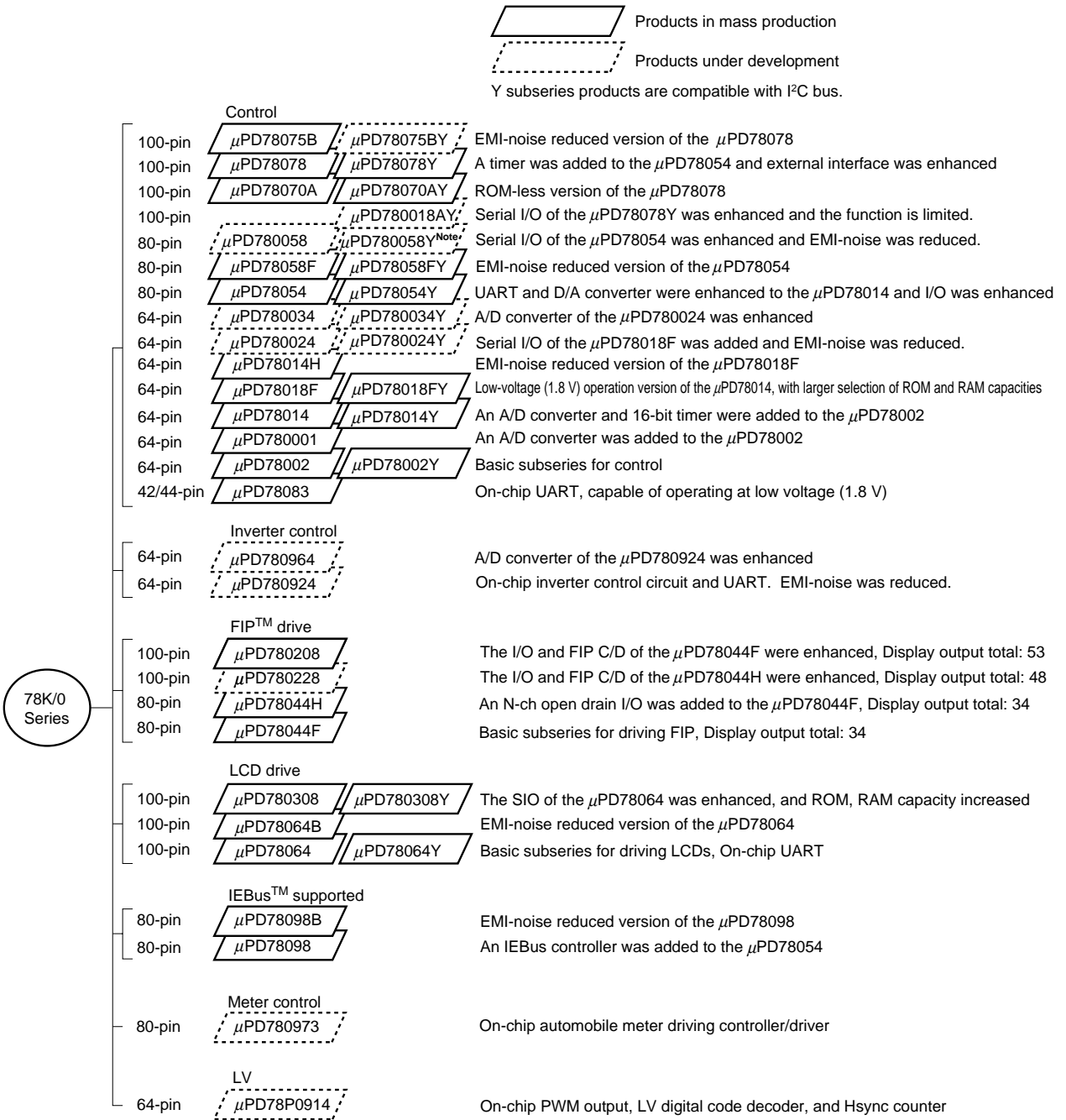
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# CHAPTER 1 GENERAL

## ★ 1.1 Product Development of 78K/0 Series

The following shows the products organized according to usage. The names in the parallelograms are subseries names.



**Note** Under planning

The following lists the main functional differences between subseries products.

| Subseries Name   | Function   | ROM Capacity | Timer |             |       |     | 8-bit A/D | 10-bit A/D | 8-bit D/A | Serial Interface              | I/O             | V <sub>DD</sub> MIN. Value | External Expansion |       |       |     |    |  |                 |       |       |
|------------------|------------|--------------|-------|-------------|-------|-----|-----------|------------|-----------|-------------------------------|-----------------|----------------------------|--------------------|-------|-------|-----|----|--|-----------------|-------|-------|
|                  |            |              | 8-bit | 16-bit      | Watch | WDT |           |            |           |                               |                 |                            |                    |       |       |     |    |  |                 |       |       |
| Control          | μPD78075B  | 32K-40K      | 4ch   | 1ch         | 1ch   | 1ch | 8ch       | -          | 2ch       | 3ch (UART: 1ch)               | 88              | 1.8 V                      | ○                  |       |       |     |    |  |                 |       |       |
|                  | μPD78078   | 48K-60K      |       |             |       |     |           |            |           |                               | 61              |                            |                    | 2.7 V |       |     |    |  |                 |       |       |
|                  | μPD78070A  | -            |       |             |       |     |           |            |           |                               | 61              |                            |                    |       |       |     |    |  |                 |       |       |
|                  | μPD780058  | 24K-60K      | 2ch   |             |       |     |           |            |           | 3ch (time division UART: 1ch) | 68              | 1.8 V                      |                    |       |       |     |    |  |                 |       |       |
|                  | μPD78058F  | 48K-60K      |       |             |       |     |           |            |           |                               | 3ch (UART: 1ch) |                            |                    | 69    | 2.7 V |     |    |  |                 |       |       |
|                  | μPD78054   | 16K-60K      |       |             |       |     |           |            |           | 2.0 V                         |                 |                            |                    |       |       |     |    |  |                 |       |       |
|                  | μPD780034  | 8K-32K       |       |             |       |     |           |            |           |                               |                 |                            |                    |       | -     | 8ch | -  | 3ch (UART: 1ch, time division 3-wire: 1ch) | 51              | 1.8 V |       |
|                  | μPD780024  |              |       |             |       |     |           |            |           |                               |                 |                            |                    |       |       |     |    |  | 8ch             |       | -     |
|                  | μPD78014H  |              |       |             |       |     |           |            |           |                               |                 |                            |                    |       |       |     |    |  | 2ch             |       | 53    |
|                  | μPD78018F  | 8K-60K       |       |             |       |     |           |            |           | 2.7 V                         |                 |                            |                    |       |       |     |    |  |                 |       |       |
|                  | μPD78014   | 8K-32K       |       |             |       |     |           |            |           |                               | 1ch             | 39                         |                    | -     |       |     |    |  |                 |       |       |
|                  | μPD780001  | 8K           |       |             |       |     |           |            |           | -                             | -               | 53                         |                    |       | ○     |     |    |  |                 |       |       |
|                  | μPD78002   | 8K-16K       |       |             |       |     |           |            |           | -                             | 1ch             | -                          |                    | 8ch   |       |     |    |  | 1ch (UART: 1ch) | 33    | 1.8 V |
| μPD78083         | -          |              |       |             |       |     |           |            |           |                               |                 |                            |                    |       |       |     |    |  |                 |       |       |
| Inverter control | μPD780964  | 8K-32K       | 3ch   | <b>Note</b> | -     | 1ch | -         | 8ch        | -         | 2ch (UART: 2ch)               | 47              | 2.7 V                      | ○                  |       |       |     |    |  |                 |       |       |
|                  | μPD780924  |              |       |             |       |     | 8ch       | -          |           |                               |                 |                            |                    |       |       |     |    |  |                 |       |       |
| FIP drive        | μPD780208  | 32K-60K      | 2ch   | 1ch         | 1ch   | 1ch | 8ch       | -          | -         | 2ch                           | 74              | 2.7 V                      | -                  |       |       |     |    |  |                 |       |       |
|                  | μPD780228  | 48K-60K      |       |             |       |     |           |            |           |                               | 3ch             |                            |                    | -     | -     | 1ch | 72 | 4.5 V                                      |                 |       |       |
|                  | μPD78044H  | 32K-48K      | 2ch   | 1ch         | 1ch   |     |           |            | 2ch       | 68                            | 2.7 V           |                            |                    |       |       |     |    |  |                 |       |       |
|                  | μPD78044F  | 16K-40K      |       |             |       |     |           |            |           |                               |                 |                            |                    |       |       |     |    |  |                 |       |       |
| LCD drive        | μPD780308  | 48K-60K      | 2ch   | 1ch         | 1ch   | 1ch | 8ch       | -          | -         | 3ch (time division UART: 1ch) | 57              | 2.0 V                      | -                  |       |       |     |    |  |                 |       |       |
|                  | μPD78064B  | 32K          |       |             |       |     |           |            |           | 2ch (UART: 1ch)               |                 |                            |                    |       |       |     |    |  |                 |       |       |
|                  | μPD78064   | 16K-32K      |       |             |       |     |           |            |           |                               |                 |                            |                    |       |       |     |    |  |                 |       |       |
| IEBus supported  | μPD78098   | 40K-60K      | 2ch   | 1ch         | 1ch   | 1ch | 8ch       | -          | 2ch       | 3ch (UART: 1ch)               | 69              | 2.7 V                      | ○                  |       |       |     |    |  |                 |       |       |
|                  | μPD78098B  | 32K-60K      |       |             |       |     |           |            |           |                               |                 |                            |                    |       |       |     |    |  |                 |       |       |
| Meter control    | μPD780973  | 24K-32K      | 3ch   | 1ch         | 1ch   | 1ch | 5ch       | -          | -         | 2ch (UART: 1ch)               | 56              | 4.5 V                      | -                  |       |       |     |    |  |                 |       |       |
| LV               | μPD78P0914 | 32K          | 6ch   | -           | -     | 1ch | 8ch       | -          | -         | 2ch                           | 54              | 4.5 V                      | ○                  |       |       |     |    |  |                 |       |       |

**Note** 10-bit timer: 1 channel

## 1.2 Features of 78K/0 Series

The 78K/0 series is a collection of 8-bit single-chip microcontrollers ideal for commercial systems.

The  $\mu$ PD78054 and 78054Y subseries are provided with peripheral hardware functions such as an A/D converter, D/A converter, timer, serial interface, real-time output port, and interrupt function.

The  $\mu$ PD78064 and 78064Y subseries are provided with peripheral hardware functions such as an LCD controller/driver, A/D converter, timer, serial interface, and interrupt function.

The  $\mu$ PD78078 and 78078Y subseries are based on the  $\mu$ PD78054 and 78054Y subseries with a timer added and the external interface function reinforced.

The  $\mu$ PD78083 subseries is provided with peripheral hardware functions such as an A/D converter, timer, serial interface, and interrupt function.

The  $\mu$ PD78098 subseries is based on the  $\mu$ PD78054 subseries with an IEBus controller added.

★ The  $\mu$ PD780018 and 780018Y subseries are versions of the  $\mu$ PD78078 and 78078Y subseries (serial interface with time division transfer function) with an improved serial interface and a limited number of functions.

★ The  $\mu$ PD780058 and 780058Y subseries are low-EMI noise versions of the  $\mu$ PD78054 and 78054Y subseries (serial interface with time division transfer function), with an improved serial interface.

★ The  $\mu$ PD780308 and 780308Y subseries are versions of the  $\mu$ PD78064 and 78064Y subseries with increased ROM and RAM with an improved serial interface.

★ The  $\mu$ PD78058F, 78058FY, 78064B, 78075B, 78075BY, and 78098B subseries are low-EMI noise versions of the  $\mu$ PD78054, 78054Y, 78064, 78078, 78078Y, and 78098 subseries.

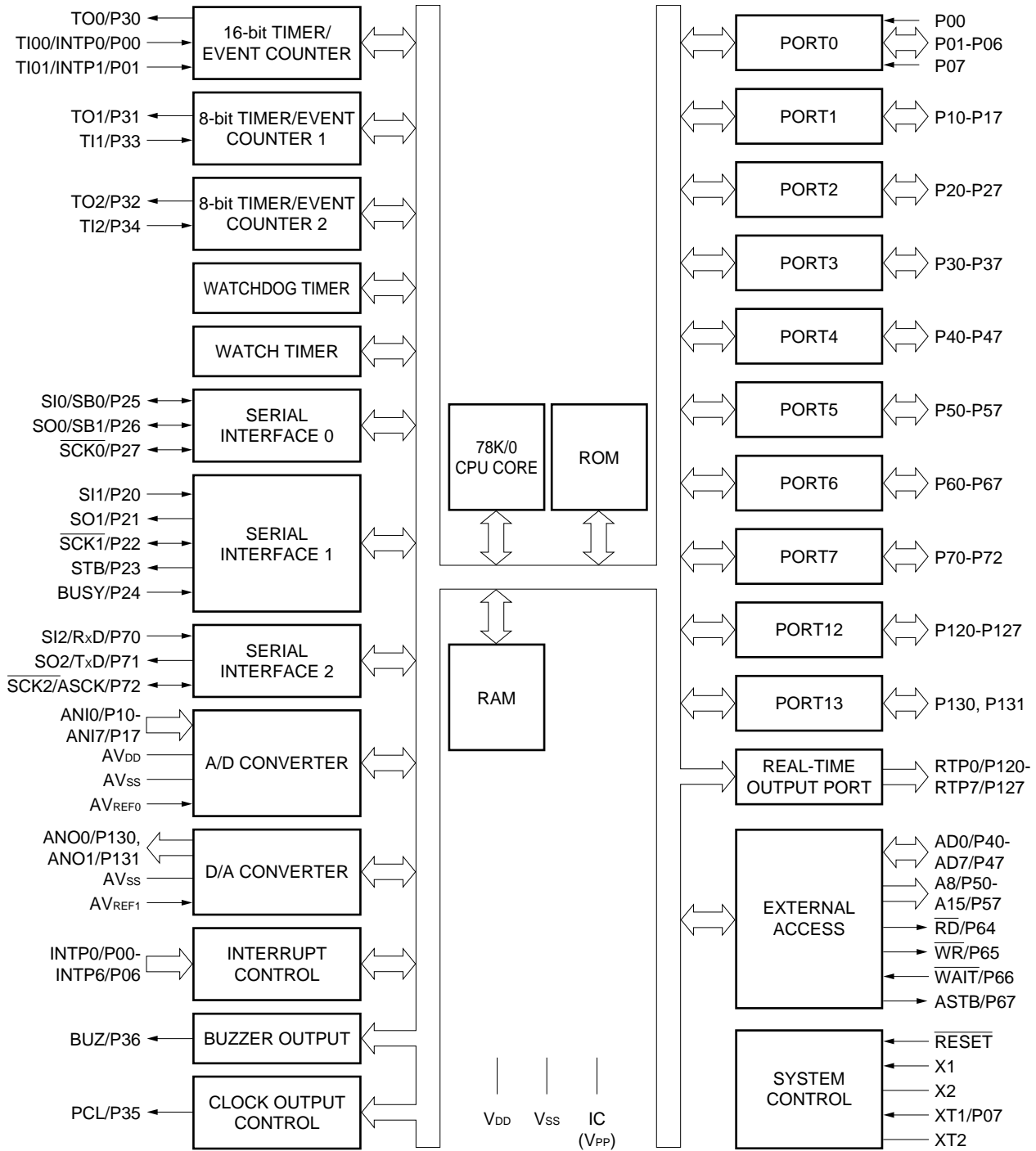
★ The  $\mu$ PD78070A and 78070AY subseries are the ROM-less versions of the  $\mu$ PD78078 and 78078Y subseries.

The  $\mu$ PD78054Y, 78064Y, 78078Y, 780058Y, 780308Y, 78058FY, 78075BY subseries and  $\mu$ PD78070AY are provided with I<sup>2</sup>C bus control function instead of the SBI function of the  $\mu$ PD78054, 78064, 78078, 780058, 780308, 78058F, 78075B subseries and  $\mu$ PD78070A.

In addition, one-time PROM, EPROM, or flash-memory models that can operate at the same operating voltage as the mask ROM models and that are ideal for early and small-scale production of the application system are also available.

The block diagram and function outline of each series is shown on the following pages.

Figure 1-1. Block Diagram of  $\mu$ PD78054 Subseries



Remarks 1. The internal ROM and RAM capacities differ depending on the model.

2. ( ):  $\mu$ PD78P054, 78P058

Table 1-1. Functional Outline of  $\mu$ PD78054 Subseries (1/2)

| Part Number                        |                        | $\mu$ PD78052  | $\mu$ PD78053 | $\mu$ PD78054 | $\mu$ PD78P054<br>Note 1     | $\mu$ PD78055 | $\mu$ PD78056 | $\mu$ PD78058 | $\mu$ PD78P058<br>Note 2     |
|------------------------------------|------------------------|--|---------------|---------------|------------------------------|---------------|---------------|---------------|------------------------------|
| Internal memory                    | ROM                    | Mask ROM   |               |               | PROM                         | Mask ROM      |               |               | PROM                         |
|                                    |                        | 16K bytes  | 24K bytes     | 32K bytes     | 32K bytes <sup>Note 2</sup>  | 40K bytes     | 48K bytes     | 60K bytes     | 60K bytes <sup>Note 3</sup>  |
|                                    | High-speed RAM         | 512 bytes  | 1024 bytes    |               | 1024 bytes <sup>Note 3</sup> | 1024 bytes    |               |               | 1024 bytes <sup>Note 3</sup> |
|                                    | Buffer RAM             | 32 bytes   |               |               |                              |               |               |               |                              |
|                                    | Expansion RAM          | None   |               |               |                              |               |               | 1024 bytes    | 1024 bytes <sup>Note 4</sup> |
| Memory space                       |                        | 64K bytes  |               |               |                              |               |               |               |                              |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks   |               |               |                              |               |               |               |                              |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)  |               |               |                              |               |               |               |                              |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)  |               |               |                              |               |               |               |                              |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>                      |               |               |                              |               |               |               |                              |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 69</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 63</li> <li>• N-ch open-drain I/O : 4</li> </ul>   |               |               |                              |               |               |               |                              |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels   |               |               |                              |               |               |               |                              |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels   |               |               |                              |               |               |               |                              |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul> |               |               |                              |               |               |               |                              |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>  |               |               |                              |               |               |               |                              |
| Timer output                       |                        | 3 (14-bit PWM output: 1)   |               |               |                              |               |               |               |                              |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)   |               |               |                              |               |               |               |                              |

**Notes** 1. The  $\mu$ PD78P054 is a PROM model of the  $\mu$ PD78052, 78053, and 78054.

2. The  $\mu$ PD78P058 is a PROM model of the  $\mu$ PD78055, 78056, and 78058.

3. The capacities of the internal PROM and internal high-speed RAM can be changed by using a memory size select register (IMS).

4. The internal expansion RAM capacity can be changed by using an internal expansion RAM size select register (IXS).

**Table 1-1. Functional Outline of  $\mu$ PD78054 Subseries (2/2)**

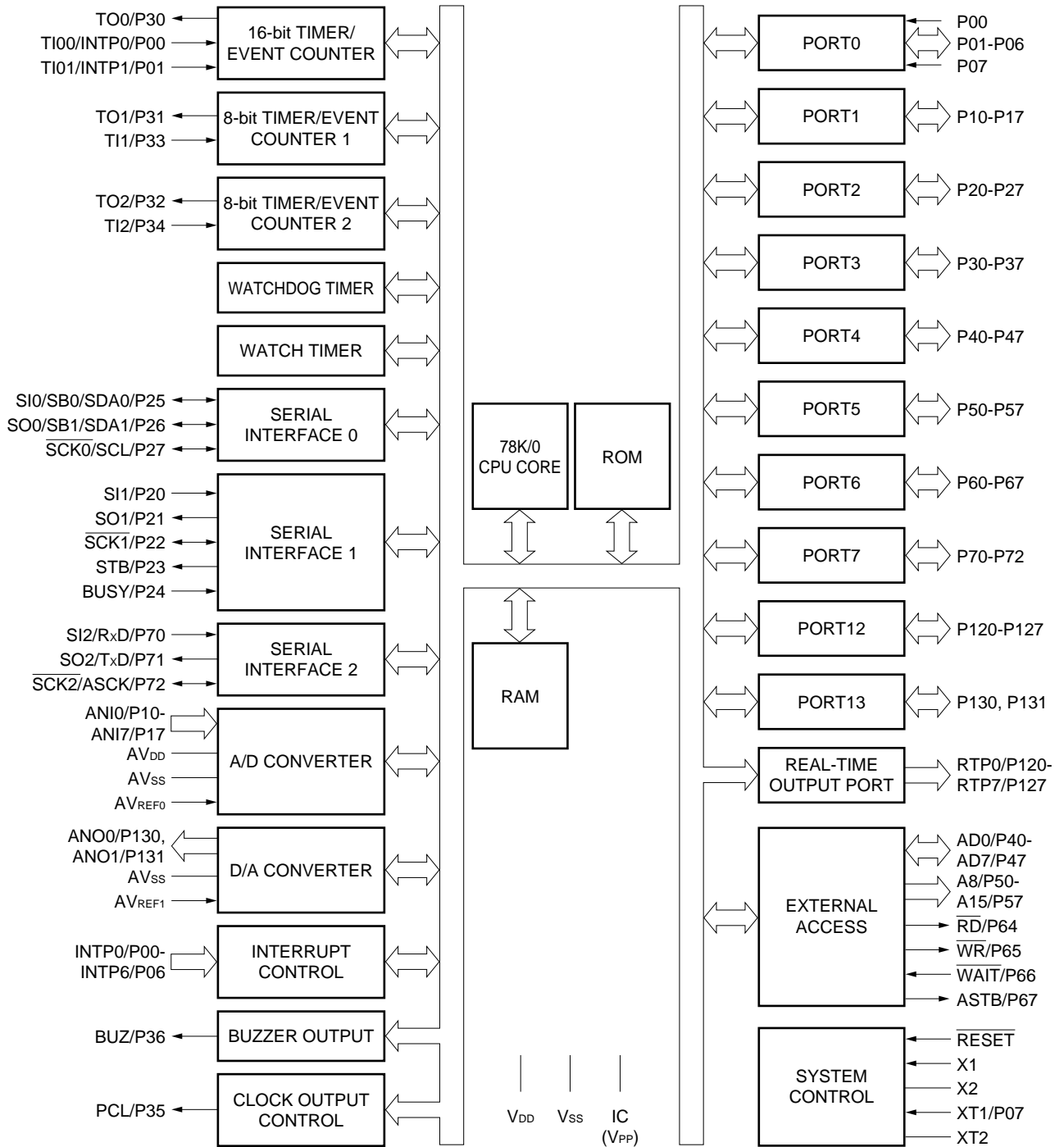
| Part Number               |              | $\mu$ PD78052  | $\mu$ PD78053 | $\mu$ PD78054 | $\mu$ PD78P054<br>Note 1 | $\mu$ PD78055 | $\mu$ PD78056 | $\mu$ PD78058 | $\mu$ PD78P058<br>Note 2 |
|---------------------------|--------------|--|---------------|---------------|--------------------------|---------------|---------------|---------------|--------------------------|
| Buzzer output             |              | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)   |               |               |                          |               |               |               |                          |
| Vectored interrupt source | Maskable     | Internal: 13, external: 7  |               |               |                          |               |               |               |                          |
|                           | Non-maskable | Internal: 1  |               |               |                          |               |               |               |                          |
|                           | Software     | 1  |               |               |                          |               |               |               |                          |
| Test input                |              | Internal: 1, external: 1   |               |               |                          |               |               |               |                          |
| Supply voltage            |              | $V_{DD} = 2.0$ to $6.0$ V  |               |               |                          |               |               |               |                          |
| Package                   |              | <ul style="list-style-type: none"> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 2.7 mm)</li> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 1.4 mm)<sup>Note 3</sup></li> <li>• 80-pin plastic TQFP (fine pitch) (<math>12 \times 12</math> mm) (<math>\mu</math>PD78052, 78053, 78054, 78P054, 78058 only)</li> <li>• 80-pin ceramic WQFN (<math>14 \times 14</math> mm) (<math>\mu</math>PD78P054, 78P058 only)</li> </ul> |               |               |                          |               |               |               |                          |

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- Notes**
1. The  $\mu$ PD78P054 is a PROM model of the  $\mu$ PD78052, 78053, and 78054.
  2. The  $\mu$ PD78P058 is a PROM model of the  $\mu$ PD78055, 78056, and 78058.
  3. Under planning



Figure 1-2. Block Diagram of  $\mu$ PD78054Y Subseries



Remarks 1. The capacities of the internal ROM and RAM differ depending on the model.

2. ( ):  $\mu$ PD78P058Y

**Table 1-2. Functional Outline of  $\mu$ PD78054Y Subseries (1/2)**

| Part Number                        |                        | $\mu$ PD78052Y  | $\mu$ PD78053Y | $\mu$ PD78054Y | $\mu$ PD78055Y | $\mu$ PD78056Y | $\mu$ PD78058Y | $\mu$ PD78P058Y              |
|------------------------------------|------------------------|---|----------------|----------------|----------------|----------------|----------------|------------------------------|
| Internal memory                    | ROM                    | Mask ROM  |                |                |                |                |                | PROM                         |
|                                    |                        | 16K bytes   | 24K bytes      | 32K bytes      | 40K bytes      | 48K bytes      | 60K bytes      | 60K bytes <sup>Note 1</sup>  |
|                                    | High-speed RAM         | 512 bytes   | 1024 bytes     |                |                |                |                | 1024 bytes <sup>Note 1</sup> |
|                                    | Buffer RAM             | 32 bytes  |                |                |                |                |                |                              |
|                                    | Expansion RAM          | None  |                |                |                |                | 1024 bytes     | 1024 bytes <sup>Note 2</sup> |
| Memory space                       |                        | 64K bytes   |                |                |                |                |                |                              |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks  |                |                |                |                |                |                              |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)   |                |                |                |                |                |                              |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)   |                |                |                |                |                |                              |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>                                     |                |                |                |                |                |                              |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 69</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 63</li> <li>• N-ch open-drain I/O : 4</li> </ul>  |                |                |                |                |                |                              |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels  |                |                |                |                |                |                              |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels  |                |                |                |                |                |                              |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/2-wire serial I/O/I<sup>2</sup>C bus mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul> |                |                |                |                |                |                              |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>   |                |                |                |                |                |                              |
| Timer output                       |                        | 3 (14-bit PWM output: 1)  |                |                |                |                |                |                              |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)  |                |                |                |                |                |                              |

- Notes**
1. The capacities of the internal PROM and internal high-speed RAM can be changed by using a memory size select register (IMS).
  2. The internal expansion RAM capacity can be changed by using an internal expansion RAM size select register (IXS).

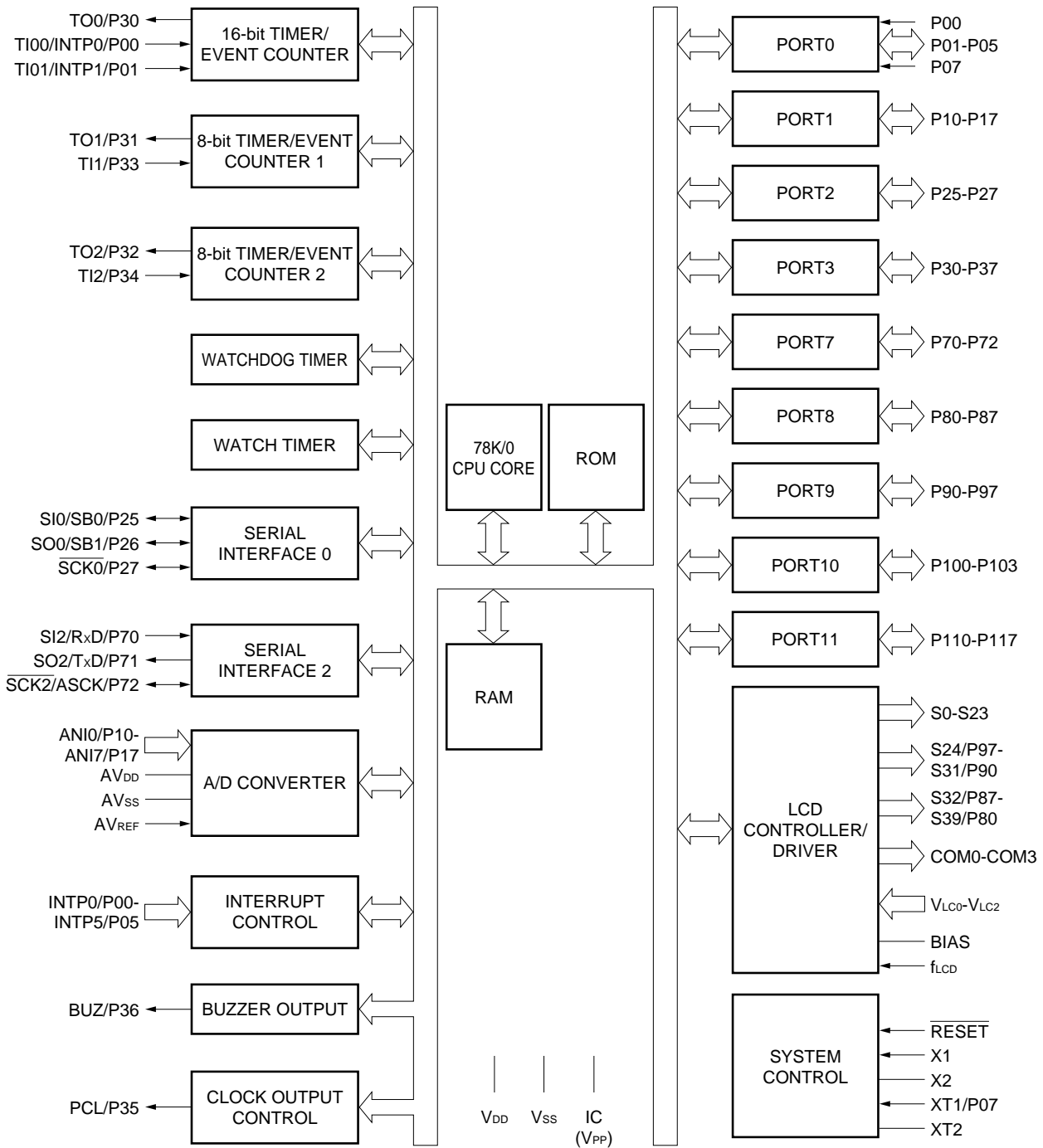
Table 1-2. Functional Outline of  $\mu$ PD78054Y Subseries (2/2)

| Item                      |              | $\mu$ PD78052Y  | $\mu$ PD78053Y | $\mu$ PD78054Y | $\mu$ PD78055Y | $\mu$ PD78056Y | $\mu$ PD78058Y | $\mu$ PD78P058Y |
|---------------------------|--------------|---|----------------|----------------|----------------|----------------|----------------|-----------------|
| Part Number               |              |   |                |                |                |                |                |                 |
| Buzzer output             |              | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)  |                |                |                |                |                |                 |
| Vectored interrupt source | Maskable     | Internal: 13, external: 7   |                |                |                |                |                |                 |
|                           | Non-maskable | Internal: 1   |                |                |                |                |                |                 |
|                           | Software     | 1   |                |                |                |                |                |                 |
| Test input                |              | Internal: 1, external: 1  |                |                |                |                |                |                 |
| Supply voltage            |              | $V_{DD} = 2.0$ to $6.0$ V   |                |                |                |                |                |                 |
| Package                   |              | <ul style="list-style-type: none"> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 2.7 mm)</li> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 1.4 mm)<sup>Note</sup></li> <li>• 80-pin ceramic WQFN (<math>14 \times 14</math> mm)(<math>\mu</math>PD78P058Y only)</li> </ul> |                |                |                |                |                |                 |

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**Note** Under planning

Figure 1-3. Block Diagram of  $\mu$ PD78064 Subseries



Remarks 1. The internal ROM and RAM capacities differ depending on the model.

2. ( ):  $\mu$ PD78P064

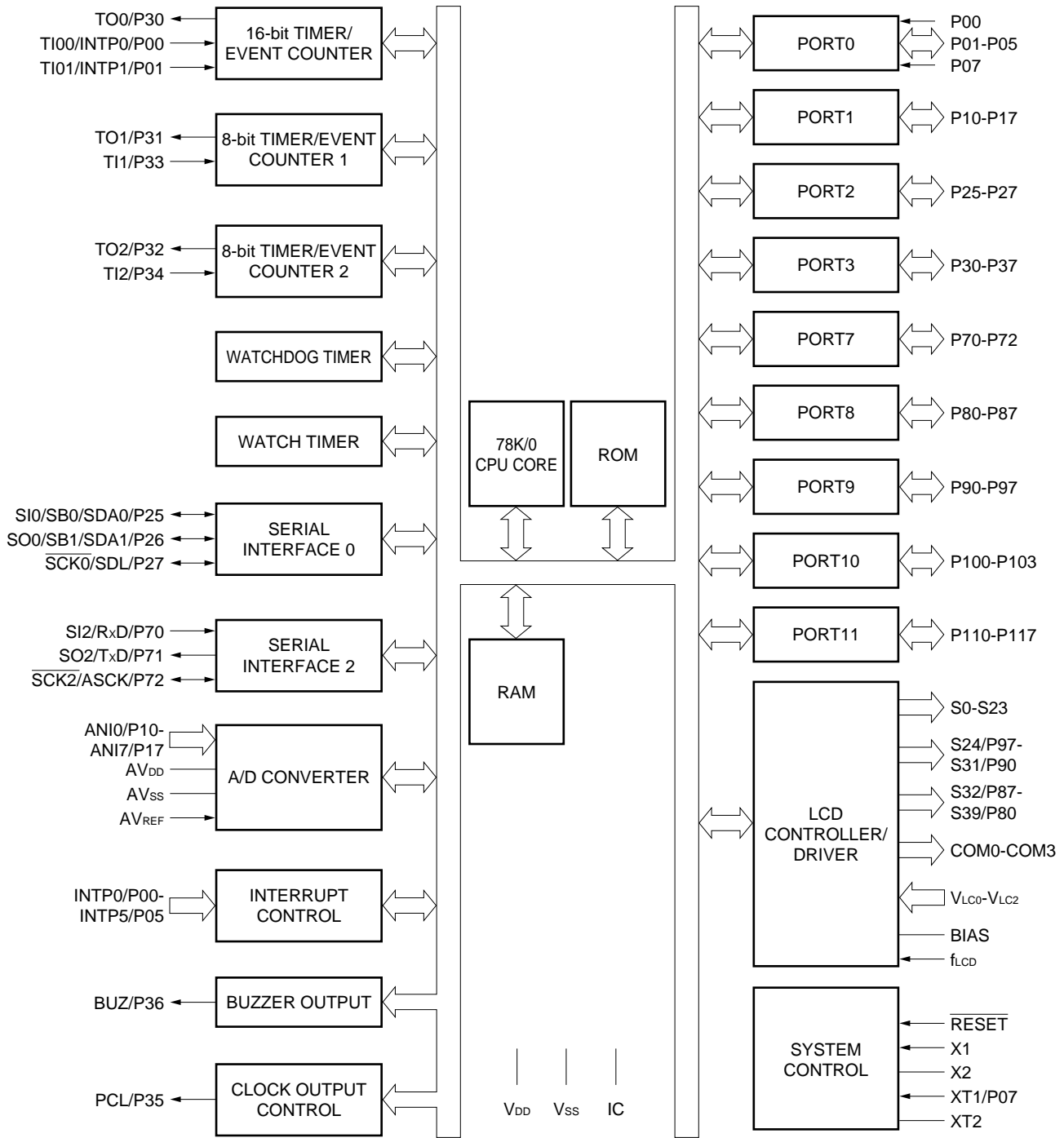
**Table 1-3. Functional Outline of  $\mu$ PD78064 Subseries**

| Part Number  |                        | $\mu$ PD78062  | $\mu$ PD78063 | $\mu$ PD78064 | $\mu$ PD78P064               |
|--|------------------------|--|---------------|---------------|------------------------------|
| Internal memory  | ROM                    | Mask ROM   |               |               | PROM                         |
|  |                        | 16K bytes  | 24K bytes     | 32K bytes     | 32K bytes <sup>Note 1</sup>  |
|  | High-speed RAM         | 512 bytes  | 1024 bytes    |               | 1024 bytes <sup>Note 1</sup> |
|  | LCD display RAM        | 40 × 4 bits  |               |               |                              |
| Memory space   |                        | 64K bytes  |               |               |                              |
| General-purpose register   |                        | 8 bits × 8 × 4 banks   |               |               |                              |
| Minimum instruction execution time                               | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)  |               |               |                              |
|  | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)  |               |               |                              |
| Instruction set  |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits × 8 bits, 16 bits ÷ 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>  |               |               |                              |
| I/O port (including pins multiplexed with segment signal output) |                        | <ul style="list-style-type: none"> <li>• Total : 57</li> <li>• CMOS input: 2</li> <li>• CMOS I/O : 55</li> </ul>   |               |               |                              |
| A/D converter  |                        | 8-bit resolution × 8 channels  |               |               |                              |
| LCD controller/driver  |                        | <ul style="list-style-type: none"> <li>• Segment signal output : 40 max.</li> <li>• Common signal output : 4 max.</li> <li>• Bias : 1/2 or 1/3 bias selectable</li> </ul>  |               |               |                              |
| Serial interface   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul>  |               |               |                              |
| Timer  |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>  |               |               |                              |
| Timer output   |                        | 3 (14-bit PWM output: 1)   |               |               |                              |
| Clock output   |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)   |               |               |                              |
| Buzzer output  |                        | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)   |               |               |                              |
| Vectored interrupt source  | Maskable               | Internal: 12, external: 6  |               |               |                              |
|  | Non-maskable           | Internal: 1  |               |               |                              |
|  | Software               | 1  |               |               |                              |
| Test input   |                        | Internal: 1, external: 1   |               |               |                              |
| Supply voltage   |                        | V <sub>DD</sub> = 2.0 to 6.0 V   |               |               |                              |
| Package  |                        | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (fine pitch) (14 × 14 mm, resin thickness 1.45 mm)</li> <li>• 100-pin plastic LQFP (fine pitch) (14 × 14 mm, resin thickness 1.4 mm)</li> <li>• 100-pin plastic QFP (14 × 20 mm)</li> <li>• 100-pin ceramic WQFN (14 × 20 mm)<sup>Note 2</sup> (<math>\mu</math>PD78P064 only)</li> </ul> |               |               |                              |

**Notes 1.** The capacities of the internal PROM and internal high-speed RAM can be changed by using a memory size select register (IMS).

**2.** Under development

Figure 1-4. Block Diagram of  $\mu$ PD78064Y Subseries



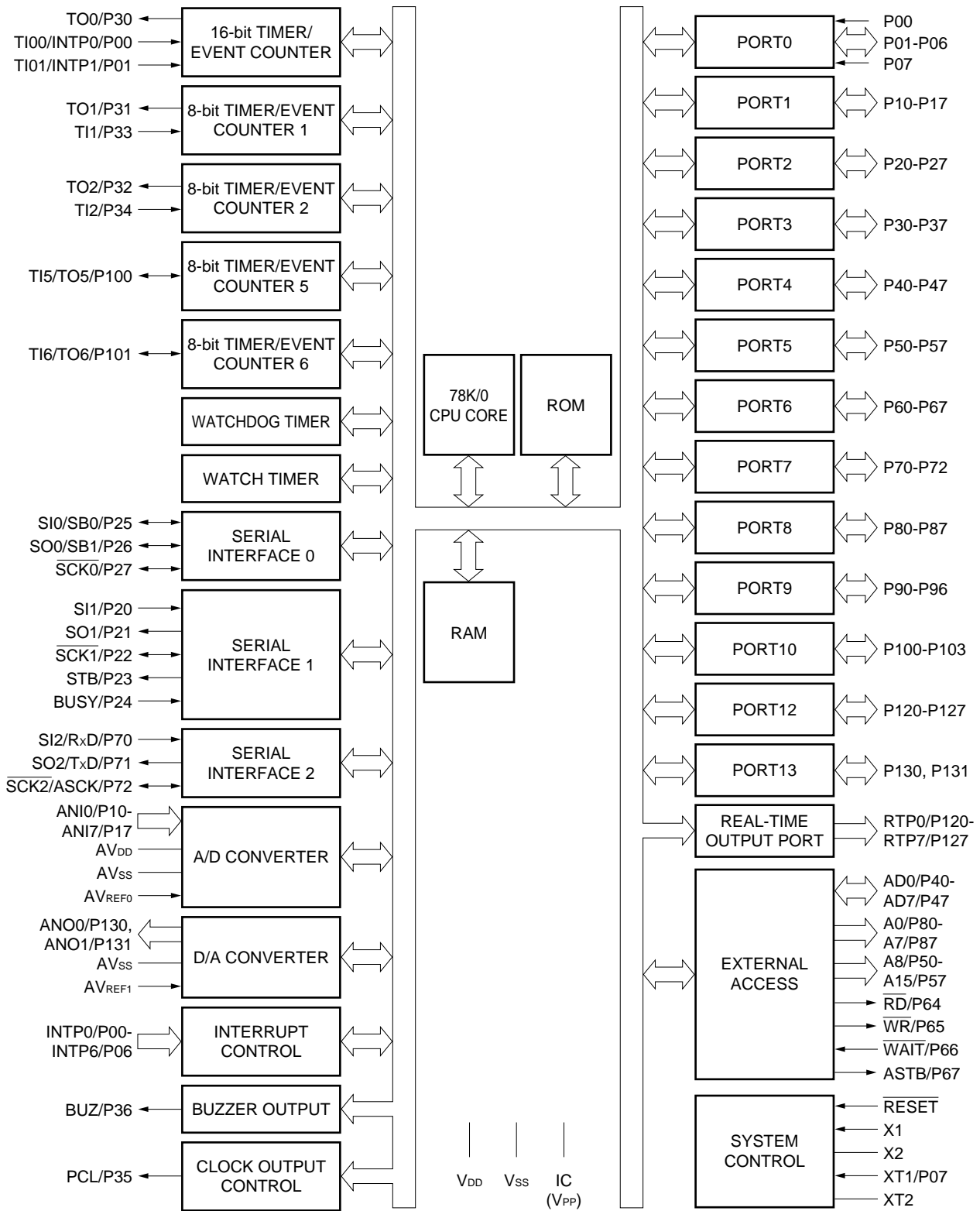
**Remark** The internal ROM and RAM capacities differ depending on the model.

Table 1-4. Functional Outline of  $\mu$ PD78064Y Subseries

| Part Number  |                        | Item        | $\mu$ PD78062Y   | $\mu$ PD78063Y | $\mu$ PD78064Y |
|--|------------------------|-------------|--|----------------|----------------|
| Internal memory  | ROM                    | Mask ROM    |  |                |                |
|  |                        | 16K bytes   | 24K bytes  | 32K bytes      |                |
|  | High-speed RAM         | 512 bytes   | 1024 bytes   |                |                |
|  | LCD display RAM        | 40 × 4 bits |  |                |                |
| Memory space   |                        |             | 64K bytes  |                |                |
| General-purpose register   |                        |             | 8 bits × 8 × 4 banks   |                |                |
| Minimum instruction execution time                               | With main system clock |             | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)  |                |                |
|  | With subsystem clock   |             | 122 $\mu$ s (at 32.768 kHz)  |                |                |
| Instruction set  |                        |             | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits × 8 bits, 16 bits ÷ 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>            |                |                |
| I/O port (including pins multiplexed with segment signal output) |                        |             | <ul style="list-style-type: none"> <li>• Total : 57</li> <li>• CMOS input: 2</li> <li>• CMOS I/O : 55</li> </ul>   |                |                |
| A/D converter  |                        |             | 8-bit resolution × 8 channels  |                |                |
| LCD controller/driver  |                        |             | <ul style="list-style-type: none"> <li>• Segment signal output : 40 max.</li> <li>• Common signal output : 4 max.</li> <li>• Bias : 1/2 or 1/3 bias selectable</li> </ul>  |                |                |
| Serial interface   |                        |             | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/2-wire serial I/O/I<sup>2</sup>C bus mode selectable : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul>   |                |                |
| Timer  |                        |             | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>                                    |                |                |
| Timer output   |                        |             | 3 (14-bit PWM output: 1)   |                |                |
| Clock output   |                        |             | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)   |                |                |
| Buzzer output  |                        |             | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)   |                |                |
| Vectored interrupt source  | Maskable               |             | Internal: 12, external: 6  |                |                |
|  | Non-maskable           |             | Internal: 1  |                |                |
|  | Software               |             | 1  |                |                |
| Test input   |                        |             | Internal: 1, external: 1   |                |                |
| Supply voltage   |                        |             | V <sub>DD</sub> = 2.0 to 6.0 V   |                |                |
| Package  |                        |             | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (fine pitch) (14 × 14 mm, resin thickness 1.45 mm)</li> <li>• 100-pin plastic LQFP (fine pitch) (14 × 14 mm, resin thickness 1.4 mm)</li> <li>• 100-pin plastic QFP (14 × 20 mm)</li> </ul> |                |                |

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Figure 1-5. Block Diagram of  $\mu$ PD78078 Subseries



Remarks 1. The internal ROM capacity differs depending on the model.

2. ( ):  $\mu$ PD78P078



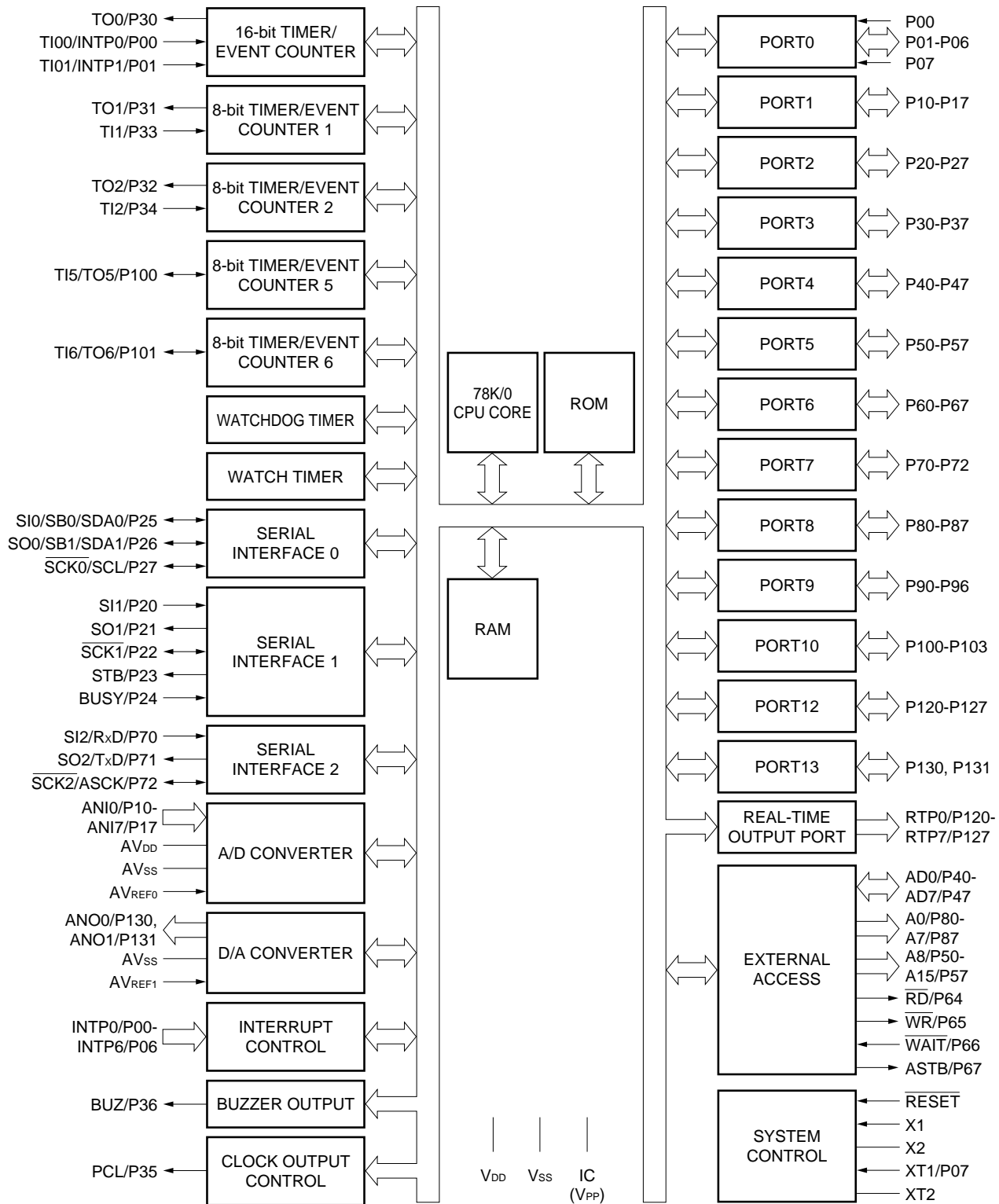
Table 1-5. Functional Outline of  $\mu$ PD78078 Subseries

| Part Number                        |                        | $\mu$ PD78076  | $\mu$ PD78078 | $\mu$ PD78P078              |
|------------------------------------|------------------------|--|---------------|-----------------------------|
| Internal memory                    | ROM                    | Mask ROM   |               | PROM                        |
|                                    |                        | 48K bytes  | 60K bytes     | 60K bytes <sup>Note 1</sup> |
|                                    | High-speed RAM         | 1024 bytes   |               |                             |
|                                    | Buffer RAM             | 32 bytes   |               |                             |
|                                    | Expansion RAM          | 1024 bytes   |               |                             |
| Memory space                       |                        | 64K bytes  |               |                             |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks   |               |                             |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)  |               |                             |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)  |               |                             |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>  |               |                             |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 88</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 78</li> <li>• N-ch open-drain I/O : 8</li> </ul>   |               |                             |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels   |               |                             |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels   |               |                             |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes): 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul>  |               |                             |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 4 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>  |               |                             |
| Timer output                       |                        | 5 (14-bit PWM output: 1, 8-bit PWM output: 2)  |               |                             |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)   |               |                             |
| Vectored interrupt source          | Maskable               | Internal: 15, external: 7  |               |                             |
|                                    | Non-maskable           | Internal: 1  |               |                             |
|                                    | Software               | 1  |               |                             |
| Test input                         |                        | Internal: 1, external: 1   |               |                             |
| Supply voltage                     |                        | $V_{DD} = 1.8$ to 5.5 V  |               |                             |
| Package                            |                        | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (fine pitch) (14 <math>\times</math> 14 mm, resin thickness 1.45 mm)</li> <li>• 100-pin plastic LQFP (fine pitch) (14 <math>\times</math> 14 mm, resin thickness 1.4 mm)<sup>Note 2</sup></li> <li>• 100-pin plastic QFP (14 <math>\times</math> 20 mm, resin thickness 2.7 mm)</li> <li>• 100-pin ceramic WQFN (14 <math>\times</math> 20 mm) (<math>\mu</math>PD78P078 only)</li> </ul> |               |                             |

**Notes 1.** The internal ROM capacity can be changed by using a memory size select register (IMS).

**2.** Under planning

Figure 1-6. Block Diagram of  $\mu$ PD78078Y Subseries



- Remarks 1.** The internal ROM capacity differs depending on the model.  
**2.** ( ):  $\mu$ PD78P078Y

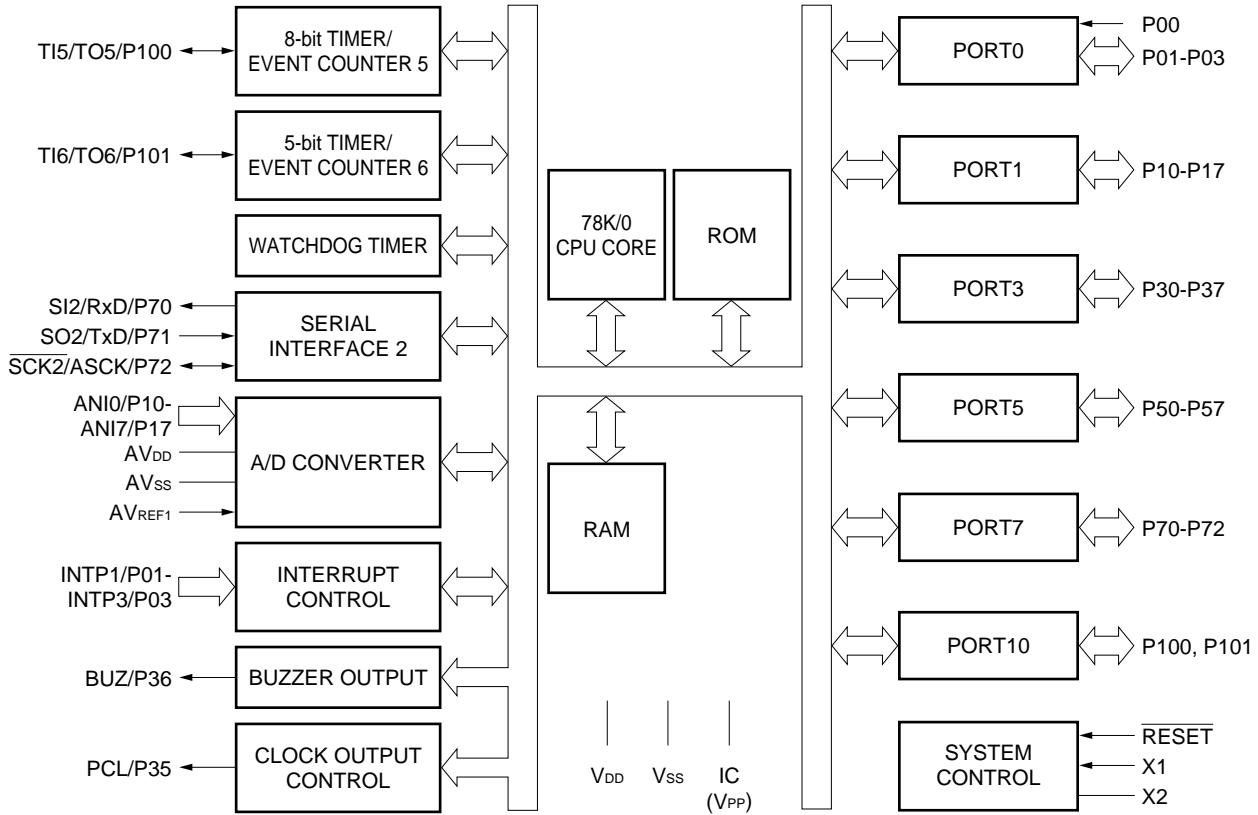
Table 1-6. Functional Outline of  $\mu$ PD78078Y Subseries

| Part Number                        |                        | $\mu$ PD78076Y  | $\mu$ PD78078Y | $\mu$ PD78P078Y             |
|------------------------------------|------------------------|---|----------------|-----------------------------|
| Internal memory                    | ROM                    | Mask ROM  |                | PROM                        |
|                                    |                        | 48K bytes   | 60K bytes      | 60K bytes <sup>Note 1</sup> |
|                                    | High-speed RAM         | 1024 bytes  |                |                             |
|                                    | Buffer RAM             | 32 bytes  |                |                             |
|                                    | Expansion RAM          | 1024 bytes  |                |                             |
| Memory space                       |                        | 64K bytes   |                |                             |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks  |                |                             |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)   |                |                             |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)   |                |                             |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>   |                |                             |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 88</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 78</li> <li>• N-ch open-drain I/O : 8</li> </ul>  |                |                             |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels  |                |                             |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels  |                |                             |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/2-wire serial I/O/I<sup>2</sup>C bus mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul>                                 |                |                             |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 4 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>   |                |                             |
| Timer output                       |                        | 5 (14-bit PWM output: 1, 8-bit PWM output: 2)   |                |                             |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)  |                |                             |
| Buzzer output                      |                        | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)  |                |                             |
| Vectored interrupt source          | Maskable               | Internal: 15, external: 7   |                |                             |
|                                    | Non-maskable           | Internal: 1   |                |                             |
|                                    | Software               | 1   |                |                             |
| Test input                         |                        | Internal: 1, external: 1  |                |                             |
| Supply voltage                     |                        | $V_{DD} = 1.8$ to 5.5 V   |                |                             |
| Package                            |                        | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (14 <math>\times</math> 20 mm, resin thickness 2.7 mm)</li> <li>• 100-pin plastic LQFP (fine pitch) (14 <math>\times</math> 14 mm, resin thickness 1.4 mm)<sup>Note 2</sup></li> <li>• 100-pin ceramic WQFN (14 <math>\times</math> 20 mm) (<math>\mu</math>PD78P078Y only)</li> </ul> |                |                             |

**Notes 1.** The internal ROM capacity can be changed by using a memory size select register (IMS).

**2.** Under development

Figure 1-7. Block Diagram of  $\mu$ PD78083 Subseries



- Remarks 1.** The internal ROM and RAM capacities differ depending on the model.  
**2.** ( ):  $\mu$ PD78P083

Table 1-7. Functional Outline of  $\mu$ PD78083 Subseries

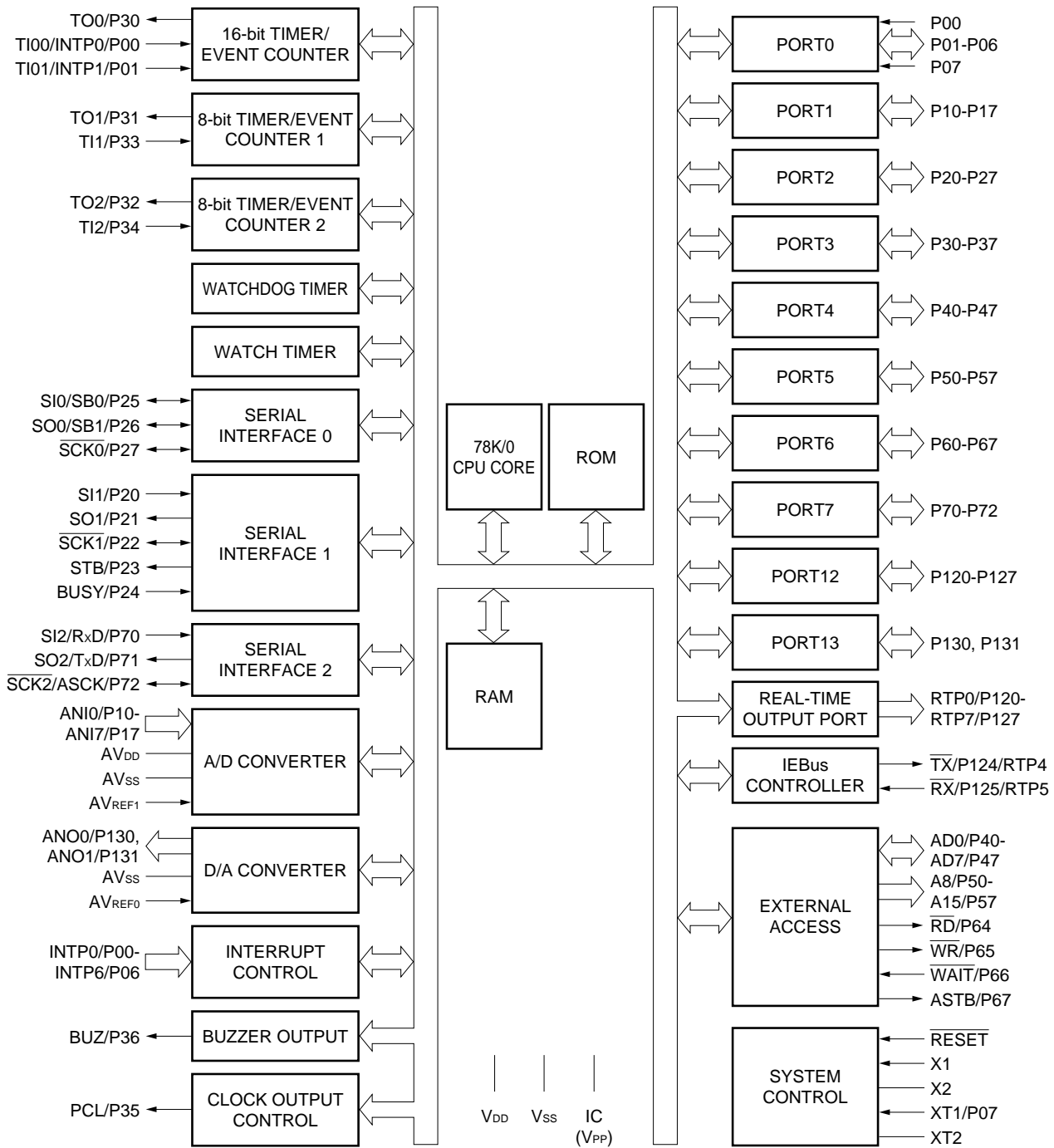
| Part Number                        |                | Item      | $\mu$ PD78081   | $\mu$ PD78082               | $\mu$ PD78P083              |
|------------------------------------|----------------|-----------|---|-----------------------------|-----------------------------|
| Internal memory                    | ROM            | Mask ROM  |   |                             | PROM                        |
|                                    |                |           | 8K bytes  | 16K bytes                   | 24K bytes <sup>Note 1</sup> |
|                                    | High-speed RAM | 256 bytes | 384 bytes   | 512 bytes <sup>Note 1</sup> |                             |
| Memory space                       |                |           | 64K bytes   |                             |                             |
| General-purpose register           |                |           | 8 bits $\times$ 8 $\times$ 4 banks  |                             |                             |
| Minimum instruction execution time |                |           | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s<br>(with main system clock of 5.0 MHz)   |                             |                             |
| Instruction set                    |                |           | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul> |                             |                             |
| I/O port                           |                |           | <ul style="list-style-type: none"> <li>• Total : 33</li> <li>• CMOS input: 1</li> <li>• CMOS I/O : 32</li> </ul>  |                             |                             |
| A/D converter                      |                |           | 8-bit resolution $\times$ 8 channels  |                             |                             |
| Serial interface                   |                |           | 3-wire serial I/O/UART mode selectable: 1 channel   |                             |                             |
| Timer                              |                |           | <ul style="list-style-type: none"> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watchdog timer : 1 channel</li> </ul>  |                             |                             |
| Timer output                       |                |           | 2 (8-bit PWM output)  |                             |                             |
| Clock output                       |                |           | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz<br>(with main system clock of 5.0 MHz)  |                             |                             |
| Buzzer output                      |                |           | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)  |                             |                             |
| Vectored interrupt source          | Maskable       |           | Internal: 8, external: 3  |                             |                             |
|                                    | Non-maskable   |           | Internal: 1   |                             |                             |
|                                    | Software       |           | 1   |                             |                             |
| Supply voltage                     |                |           | $V_{DD} = 1.8$ to $5.5$ V <sup>Note 2</sup>   |                             |                             |
| Package                            |                |           | <ul style="list-style-type: none"> <li>• 42-pin plastic shrink DIP (600 mil)</li> <li>• 42-pin ceramic shrink DIP (with window) (600 mil) (<math>\mu</math>PD78P083 only)</li> <li>• 44-pin plastic QFP (10 <math>\times</math> 10 mm)</li> </ul>                               |                             |                             |

**Notes 1.** The capacities of the internal PROM and internal-high-speed RAM can be changed by using a memory size select register. (IMS)

★

**2.** The supply voltage ( $V_{DD}$ ) of the  $\mu$ PD78081(A2) is 4.5 to 5.5 V.

Figure 1-8. Block Diagram of  $\mu$ PD78098 Subseries



Remarks 1. The internal ROM and RAM capacities differ depending on the model.

2. ( ):  $\mu$ PD78P098A

Table 1-8. Functional Outline of  $\mu$ PD78098 Subseries (1/2)

| Part Number                        |                        | $\mu$ PD78094  | $\mu$ PD78095 | $\mu$ PD78096 | $\mu$ PD78098A <sup>Note 1</sup> | $\mu$ PD78P098A <sup>Note 1, 2</sup> |
|------------------------------------|------------------------|--|---------------|---------------|----------------------------------|--------------------------------------|
| Internal memory                    | ROM                    | Mask ROM   |               |               |                                  | PROM                                 |
|                                    |                        | 32K bytes  | 40K bytes     | 48K bytes     | 60K bytes                        | 60K bytes <sup>Note 3</sup>          |
|                                    | High-speed RAM         | 1024 bytes   |               |               |                                  |                                      |
|                                    | Buffer RAM             | 32 bytes   |               |               |                                  |                                      |
|                                    | Expansion RAM          | None   |               |               | 2048 bytes                       | 2048 bytes <sup>Note 4</sup>         |
| Memory space                       |                        | 64K bytes  |               |               |                                  |                                      |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks   |               |               |                                  |                                      |
| Minimum instruction execution time | With main system clock | 0.5 $\mu$ s/1.0 $\mu$ s/2.0 $\mu$ s/4.0 $\mu$ s/8.0 $\mu$ s/16.0 (at 6.0 MHz)  |               |               |                                  |                                      |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)  |               |               |                                  |                                      |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>                      |               |               |                                  |                                      |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 69</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 63</li> <li>• N-ch open-drain I/O: 4</li> </ul>  |               |               |                                  |                                      |
| IEBus controller                   |                        | Effective transfer rate: 3.9 kbps/17 kbps/26 kbps  |               |               |                                  |                                      |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels   |               |               |                                  |                                      |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels   |               |               |                                  |                                      |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul> |               |               |                                  |                                      |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>  |               |               |                                  |                                      |
| Timer output                       |                        | 3 (14-bit PWM output: 1)   |               |               |                                  |                                      |
| Clock output                       |                        | 15.6 kHz, 31.3 kHz, 62.5 kHz, 125 kHz, 250 kHz, 500 kHz, 1.0 MHz, 2.0 MHz, 4.0 MHz (with main system clock of 6.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)  |               |               |                                  |                                      |

**Notes** 1. Under development

2. The  $\mu$ PD78P098A is the PROM model of the  $\mu$ PD78094, 78095, 78096, and 78098A.

3. The internal PROM capacity can be changed by using a memory size select register (IMS).

4. The internal expansion RAM can be changed by using an internal expansion RAM size select register (IXS).

**Table 1-8. Functional Outline of  $\mu$ PD78098 Subseries (2/2)**

| Part Number               |              | Item | $\mu$ PD78094   | $\mu$ PD78095 | $\mu$ PD78096 | $\mu$ PD78098A <sup>Note 1</sup> | $\mu$ PD78P098A <sup>Note 1, 2</sup> |
|---------------------------|--------------|------|---|---------------|---------------|----------------------------------|--------------------------------------|
| Buzzer output             |              |      | 977 Hz, 1.95 kHz, 3.9 kHz, 7.8 kHz (with main system clock of 6.0 MHz)  |               |               |                                  |                                      |
| Vectored interrupt source | Maskable     |      | Internal: 14, external: 7   |               |               |                                  |                                      |
|                           | Non-maskable |      | Internal: 1   |               |               |                                  |                                      |
|                           | Software     |      | 1   |               |               |                                  |                                      |
| Test input                |              |      | Internal: 1, external: 1  |               |               |                                  |                                      |
| Supply voltage            |              |      | $V_{DD} = 2.7$ to 6.0 V   |               |               |                                  |                                      |
| Package                   |              |      | <ul style="list-style-type: none"> <li>• 80-pin plastic QFP (14 × 14 mm)</li> <li>• 80-pin ceramic WQFN (14 × 14 mm)<sup>Note 1</sup> (<math>\mu</math>PD78P098A only)</li> </ul> |               |               |                                  |                                      |

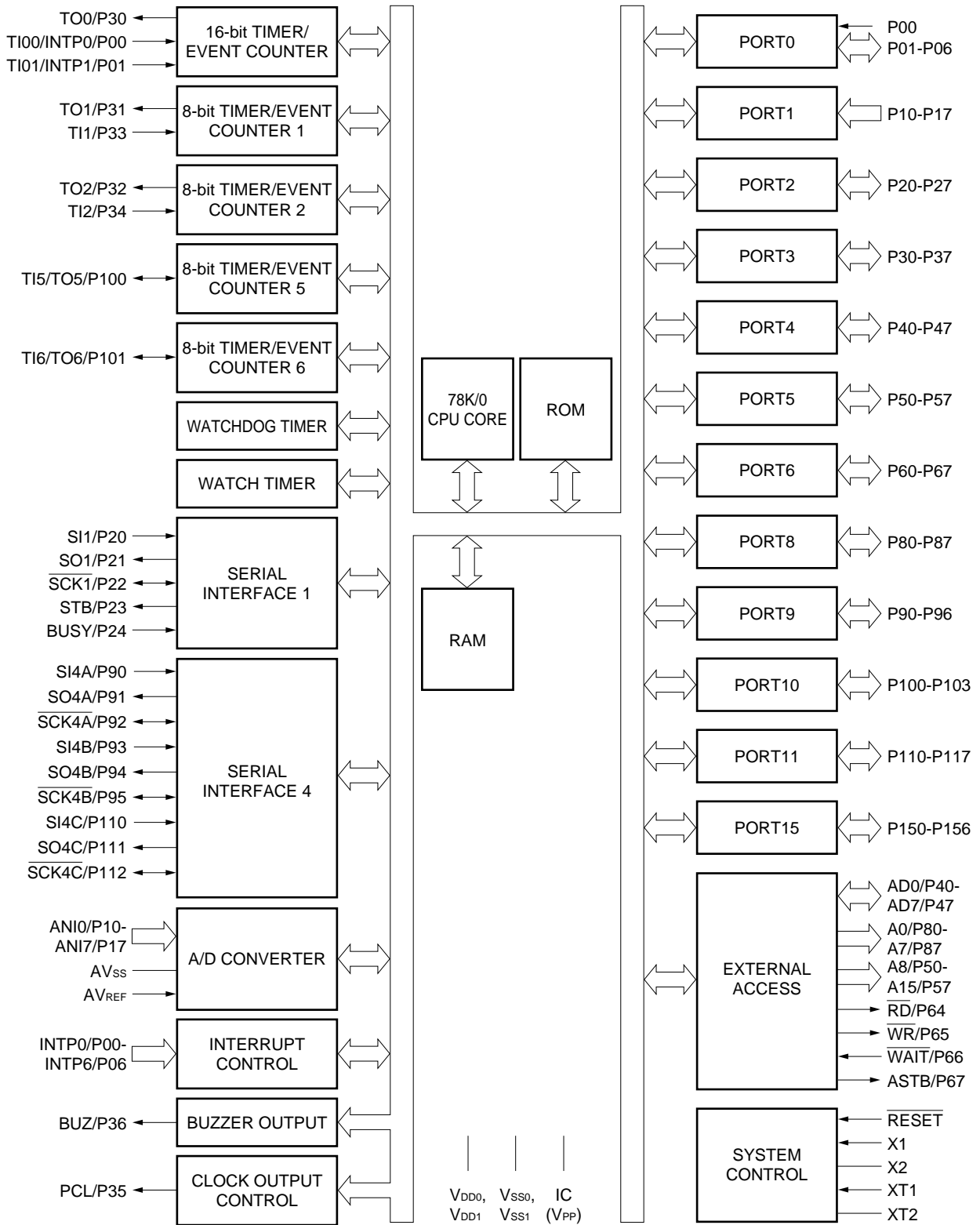
**Notes 1.** Under development

**2.** The  $\mu$ PD78P098A is a PROM model of the  $\mu$ PD78094, 78095, 78096, and 78098A.



★

Figure 1-9. Block Diagram of  $\mu$ PD780018 Subseries



Remarks 1. The internal ROM capacity differs depending on the model.

2. ( ):  $\mu$ PD78P0018



**Table 1-9. Functional Outline of  $\mu$ PD780018 Subseries (1/2)**

| Part Number                        |                        | Item  | $\mu$ PD780016 | $\mu$ PD780018            | $\mu$ PD78P0018 |
|------------------------------------|------------------------|---|----------------|---------------------------|-----------------|
| Internal memory                    | ROM                    | Mask ROM  |                |                           | PROM            |
|                                    |                        | 48K bytes   | 60K bytes      | 60K bytes <sup>Note</sup> |                 |
|                                    | High-speed RAM         | 1024 bytes  |                |                           |                 |
|                                    | Buffer RAM             | 32 bytes  |                |                           |                 |
|                                    | Expansion RAM          | 1024 bytes  |                |                           |                 |
| Memory space                       |                        | 64K bytes   |                |                           |                 |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks  |                |                           |                 |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s (at 5.0 MHz)  |                |                           |                 |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)   |                |                           |                 |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul> |                |                           |                 |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 88</li> <li>• CMOS input : 9</li> <li>• CMOS I/O : 79</li> </ul>   |                |                           |                 |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels  |                |                           |                 |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O mode (with automatical transfer/reception function) : 1 channel</li> <li>• 3-wire serial I/O mode selectable (with time-division transfer function) : 1 channel</li> </ul>   |                |                           |                 |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 4 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>   |                |                           |                 |
| Timer output                       |                        | 5 (14-bit PWM output: 1, 8-bit PWM output: 2)   |                |                           |                 |
| Clock output                       |                        | 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)  |                |                           |                 |

**Note** The internal ROM capacity can be changed by using a memory size select register. (IMS)

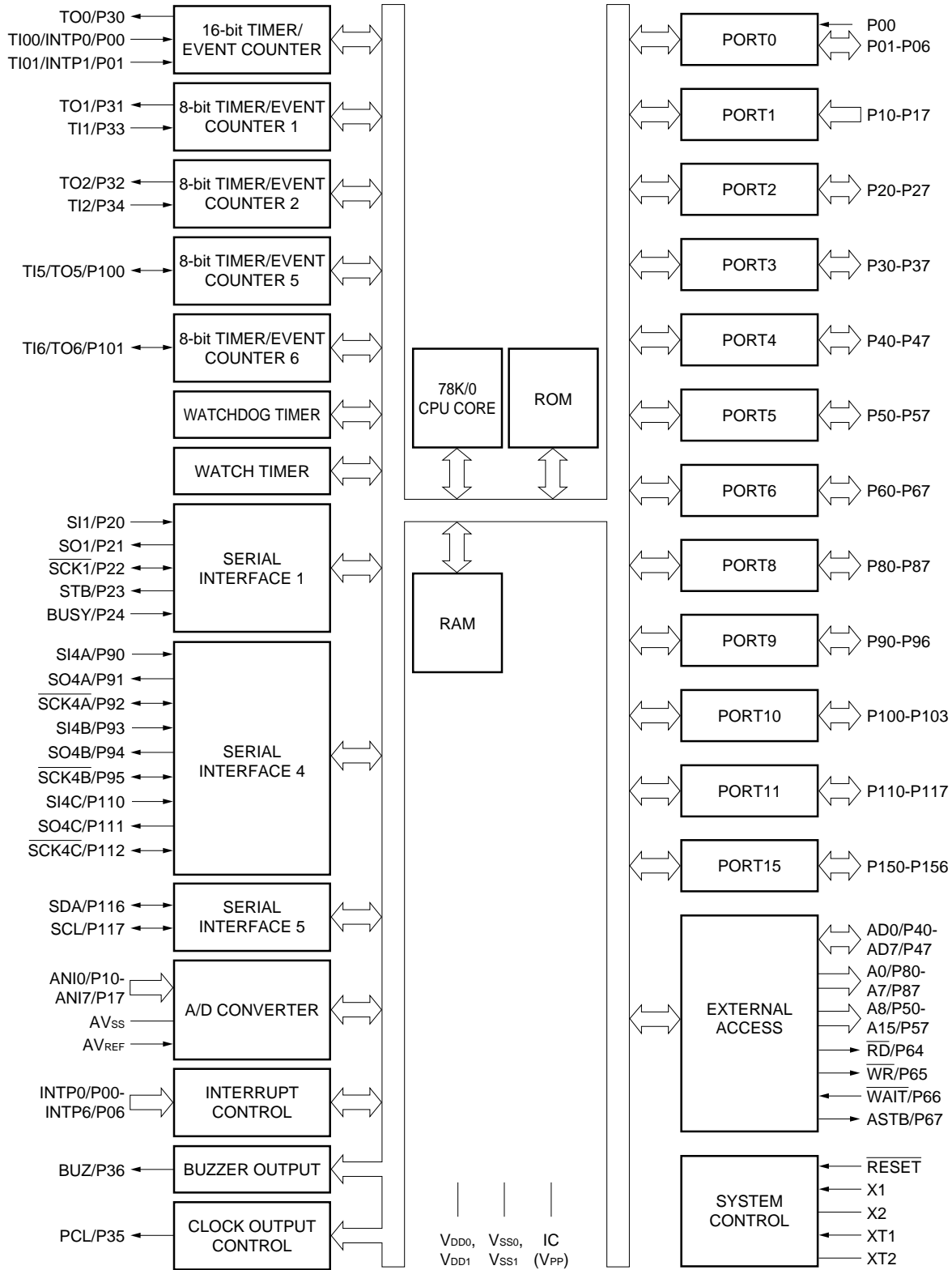
**Caution** The  $\mu$ PD780018 subseries is under planning.

Table 1-9. Functional Outline of  $\mu$ PD780018 Subseries (2/2)

| Part Number               |              | $\mu$ PD780016   | $\mu$ PD780018 | $\mu$ PD78P0018 |
|---------------------------|--------------|--|----------------|-----------------|
| Buzzer output             |              | 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)  |                |                 |
| Vectored interrupt source | Maskable     | Internal: 12, external: 7  |                |                 |
|                           | Non-maskable | Internal: 1  |                |                 |
|                           | Software     | 1  |                |                 |
| Test input                |              | Internal: 1, external: 1   |                |                 |
| Supply voltage            |              | $V_{DD} = 2.7$ to $5.5$ V  |                |                 |
| Operating temperature     |              | $T_A = -40$ to $+85$ °C  |                |                 |
| Package                   |              | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (14 × 20 mm)</li> <li>• 100-pin ceramic WQFN (14 × 20 mm) (<math>\mu</math>PD78P0018 only)</li> </ul> |                |                 |

**Caution** The  $\mu$ PD780018 subseries is under planning.

★ **Figure 1-10. Block Diagram of  $\mu$ PD780018Y Subseries**



**Remarks 1.** The internal ROM capacity differs depending on the model.

**2.** ( ):  $\mu$ PD78P0018Y

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Table 1-10. Functional Outline of  $\mu$ PD780018Y Subseries (1/2)

| Part Number                        |                        | Item   | $\mu$ PD780016Y | $\mu$ PD780018Y | $\mu$ PD78P018Y           |
|------------------------------------|------------------------|--|-----------------|-----------------|---------------------------|
| Internal memory                    | ROM                    | Mask ROM   |                 |                 | PROM                      |
|                                    |                        | 48K bytes  |                 | 60K bytes       | 60K bytes <sup>Note</sup> |
|                                    | High-speed RAM         | 1024 bytes   |                 |                 |                           |
|                                    | Buffer RAM             | 32 bytes   |                 |                 |                           |
|                                    | Expansion RAM          | 1024 bytes   |                 |                 |                           |
| Memory space                       |                        | 64K bytes  |                 |                 |                           |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks   |                 |                 |                           |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s (at 5.0 MHz)   |                 |                 |                           |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)  |                 |                 |                           |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>                                |                 |                 |                           |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 88</li> <li>• CMOS input : 9</li> <li>• CMOS I/O : 79</li> </ul>  |                 |                 |                           |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels   |                 |                 |                           |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O mode (with automatical transfer/reception function) : 1 channel</li> <li>• 3-wire serial I/O mode selectable (with time-division transfer function) : 1 channel</li> <li>• I<sup>2</sup>C bus mode (multi-master compatible) : 1 channel</li> </ul> |                 |                 |                           |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 4 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>  |                 |                 |                           |
| Timer output                       |                        | 5 (14-bit PWM output: 1, 8-bit PWM output: 2)  |                 |                 |                           |
| Clock output                       |                        | 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)   |                 |                 |                           |

**Note** The internal PROM capacity can be changed by using a memory size select register. (IMS)

**Caution** The  $\mu$ PD780018Y subseries is under development.

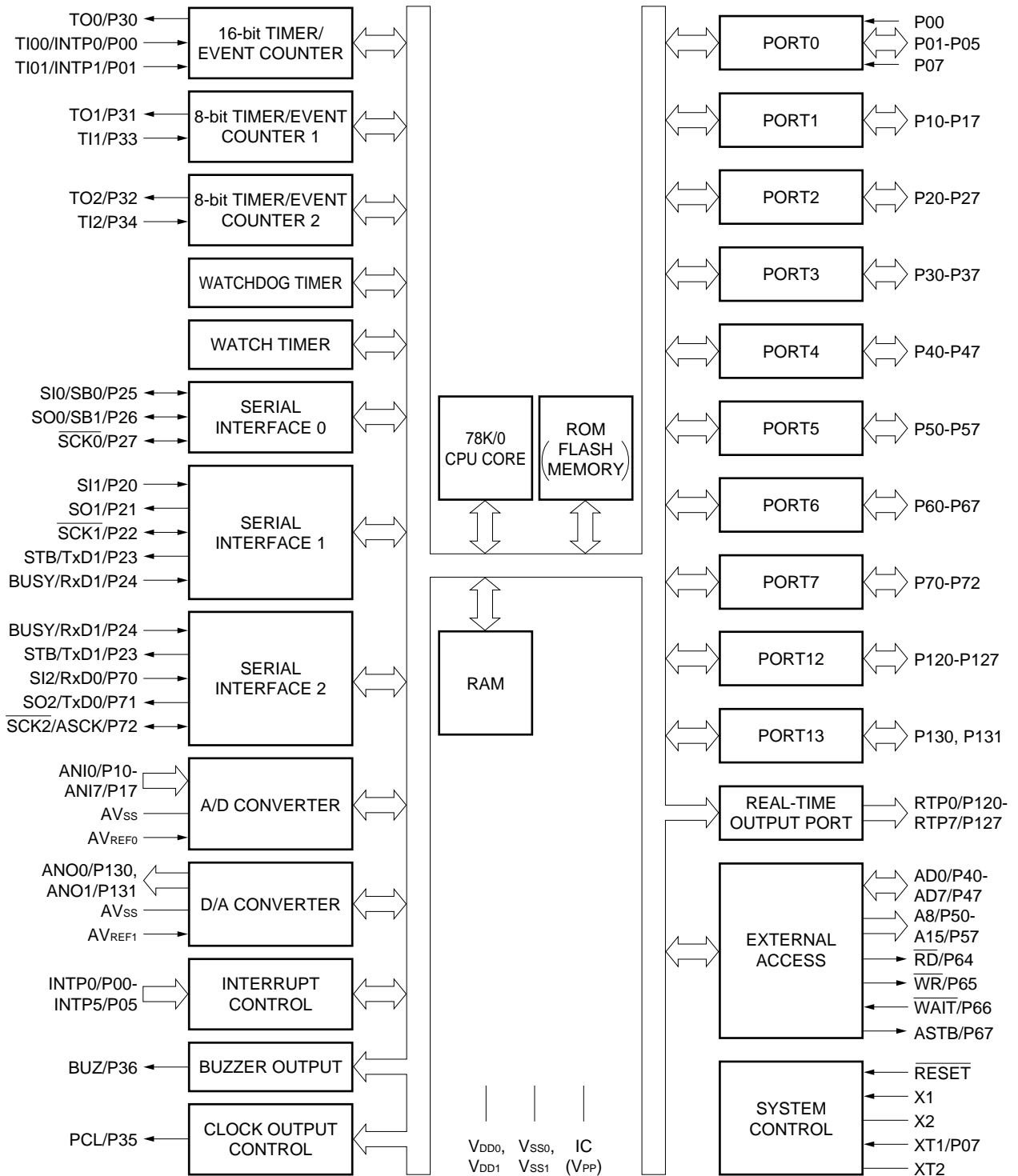
Table 1-10. Functional Outline of  $\mu$ PD78P0018Y Subseries (2/2)

| Part Number               |              | $\mu$ PD780016Y   | $\mu$ PD780018Y | $\mu$ PD78P018Y |
|---------------------------|--------------|---|-----------------|-----------------|
| Buzzer output             |              | 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)   |                 |                 |
| Vectored interrupt source | Maskable     | Internal: 12, external: 7   |                 |                 |
|                           | Non-maskable | Internal: 1   |                 |                 |
|                           | Software     | 1   |                 |                 |
| Test input                |              | Internal: 1, external: 1  |                 |                 |
| Supply voltage            |              | $V_{DD} = 2.7$ to $5.5$ V   |                 |                 |
| Operating temperature     |              | $T_A = -40$ to $+85$ °C   |                 |                 |
| Package                   |              | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (14 × 20 mm)</li> <li>• 100-pin ceramic WQFN (14 × 20 mm) (<math>\mu</math>PD78P0018Y only)</li> </ul> |                 |                 |

**Caution** The  $\mu$ PD780018Y subseries is under development.



Figure 1-11. Block Diagram of  $\mu$ PD780058 Subseries



**Remarks 1.** The capacities of the internal ROM and RAM differ depending on the model.

**2.** ( ):  $\mu$ PD78F0058



**Table 1-11. Functional Outline of  $\mu$ PD780058 Subseries (1/2)**

| Part Number                        |                        | $\mu$ PD780053  | $\mu$ PD780054 | $\mu$ PD780055 | $\mu$ PD780056 | $\mu$ PD780058 | $\mu$ PD78F0058              |  |
|------------------------------------|------------------------|---|----------------|----------------|----------------|----------------|------------------------------|--|
| Internal memory                    | ROM                    | Mask ROM  |                |                |                |                | Flash memory                 |  |
|                                    |                        | 24K bytes   | 32K bytes      | 40K bytes      | 48K bytes      | 60K bytes      | 60K bytes <sup>Note 1</sup>  |  |
|                                    | High-speed RAM         | 1024 bytes  |                |                |                |                |                              |  |
|                                    | Buffer RAM             | 32 bytes  |                |                |                |                |                              |  |
|                                    | Expansion RAM          | None  |                |                |                | 1024 bytes     | 1024 bytes <sup>Note 2</sup> |  |
| Memory space                       |                        | 64K bytes   |                |                |                |                |                              |  |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks  |                |                |                |                |                              |  |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)   |                |                |                |                |                              |  |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)   |                |                |                |                |                              |  |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>   |                |                |                |                |                              |  |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 68</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 62</li> <li>• N-ch open-drain I/O : 4</li> </ul>  |                |                |                |                |                              |  |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels  |                |                |                |                |                              |  |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels  |                |                |                |                |                              |  |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable (with time-division transfer function) : 1 channel</li> </ul> |                |                |                |                |                              |  |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>   |                |                |                |                |                              |  |
| Timer output                       |                        | 3 (14-bit PWM output: 1)  |                |                |                |                |                              |  |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)  |                |                |                |                |                              |  |

- Notes**
1. The capacities of the flash memory can be changed by using a memory size select register (IMS).
  2. The internal expansion RAM capacity can be changed by using an internal expansion RAM size select register (IXS).

**Caution** The  $\mu$ PD780058 subseries is under development.



★

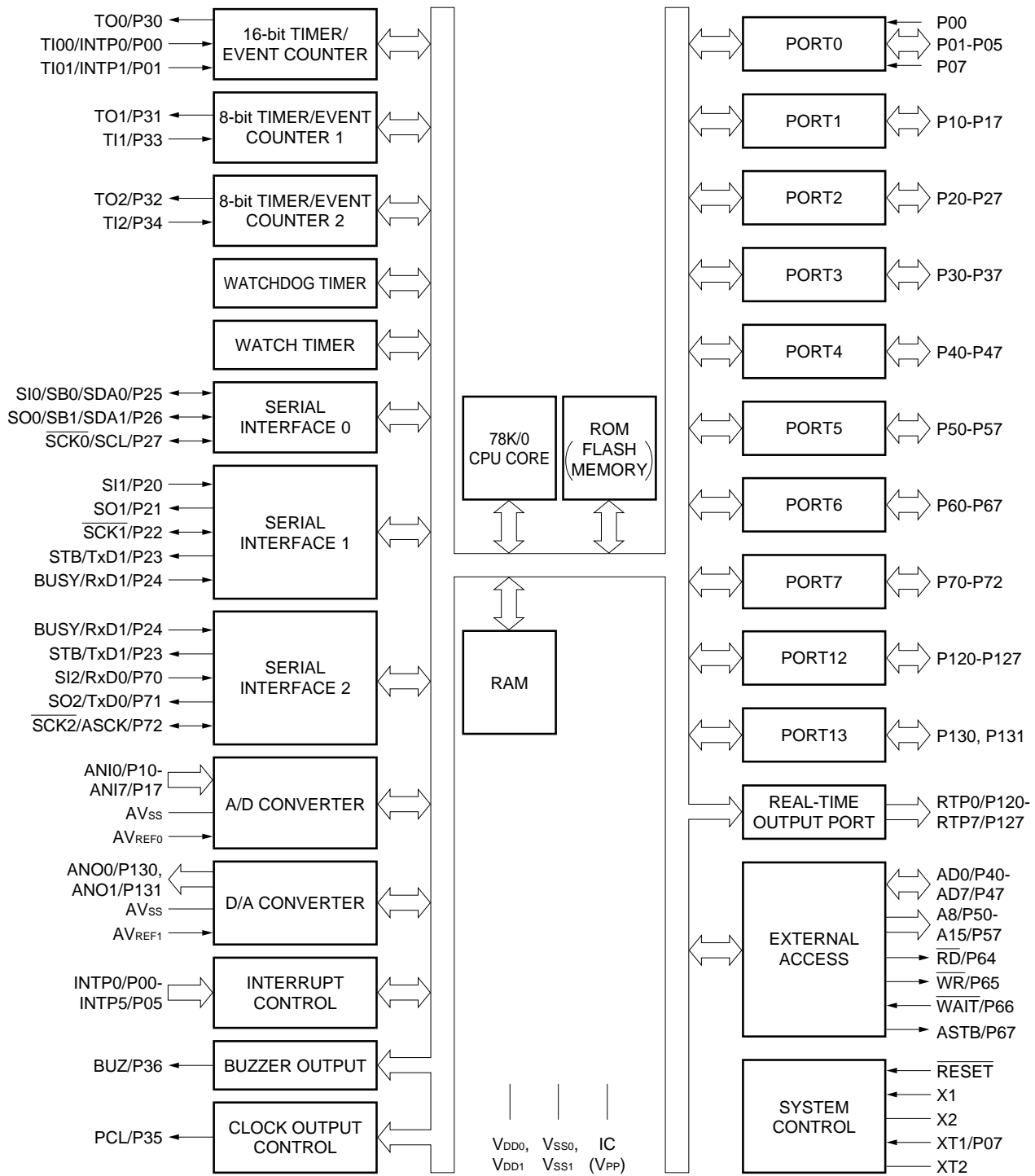
Table 1-11. Functional Outline of  $\mu$ PD780058 Subseries (2/2)

| Part Number               |              | $\mu$ PD780053   | $\mu$ PD780054 | $\mu$ PD780055 | $\mu$ PD780056 | $\mu$ PD780058 | $\mu$ PD78F0058 |
|---------------------------|--------------|--|----------------|----------------|----------------|----------------|-----------------|
| Buzzer output             |              | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)   |                |                |                |                |                 |
| Vectored interrupt source | Maskable     | Internal: 13, external: 7  |                |                |                |                |                 |
|                           | Non-maskable | Internal: 1  |                |                |                |                |                 |
|                           | Software     | 1  |                |                |                |                |                 |
| Test input                |              | Internal: 1, external: 1   |                |                |                |                |                 |
| Supply voltage            |              | $V_{DD} = 1.8$ to $5.5$ V  |                |                |                |                |                 |
| Operating temperature     |              | $T_A = -40$ to $+85$ °C  |                |                |                |                |                 |
| Package                   |              | <ul style="list-style-type: none"> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 2.7 mm)</li> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 1.4 mm)<sup>Note</sup></li> <li>• 80-pin plastic TQFP (fine pitch) (<math>12 \times 12</math> mm)</li> </ul> |                |                |                |                |                 |

**Note** Under planning

**Caution** The  $\mu$ PD780058 subseries is under development.

Figure 1-12. Block Diagram of  $\mu$ PD780058Y Subseries



Remarks 1. The capacities of the internal ROM and RAM differ depending on the model.

2. ( ):  $\mu$ PD78F0058Y



**Table 1-12. Functional Outline of  $\mu$ PD780058Y Subseries (1/2)**

| Part Number                        |                        | $\mu$ PD780053Y  | $\mu$ PD780054Y | $\mu$ PD780055Y | $\mu$ PD780056Y | $\mu$ PD780058Y | $\mu$ PD78F0058Y             |  |
|------------------------------------|------------------------|--|-----------------|-----------------|-----------------|-----------------|------------------------------|--|
| Internal memory                    | ROM                    | Mask ROM   |                 |                 |                 |                 | Flash memory                 |  |
|                                    |                        | 24K bytes  | 32K bytes       | 40K bytes       | 48K bytes       | 60K bytes       | 60K bytes <sup>Note 1</sup>  |  |
|                                    | High-speed RAM         | 1024 bytes   |                 |                 |                 |                 |                              |  |
|                                    | Buffer RAM             | 32 bytes   |                 |                 |                 |                 |                              |  |
|                                    | Expansion RAM          | None   |                 |                 |                 | 1024 bytes      | 1024 bytes <sup>Note 2</sup> |  |
| Memory space                       |                        | 64K bytes  |                 |                 |                 |                 |                              |  |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks   |                 |                 |                 |                 |                              |  |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)  |                 |                 |                 |                 |                              |  |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)  |                 |                 |                 |                 |                              |  |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>  |                 |                 |                 |                 |                              |  |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 68</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 62</li> <li>• N-ch open-drain I/O : 4</li> </ul>   |                 |                 |                 |                 |                              |  |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels   |                 |                 |                 |                 |                              |  |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels   |                 |                 |                 |                 |                              |  |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/2-wire serial I/O/I<sup>2</sup>C bus mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable (with time-division transfer function) : 1 channel</li> </ul> |                 |                 |                 |                 |                              |  |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>  |                 |                 |                 |                 |                              |  |
| Timer output                       |                        | 3 (14-bit PWM output: 1)   |                 |                 |                 |                 |                              |  |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)   |                 |                 |                 |                 |                              |  |

- Notes**
1. The capacities of the flash memory can be changed by using a memory size select register (IMS).
  2. The internal expansion RAM capacity can be changed by using an internal expansion RAM size select register (IXS).

**Caution** The  $\mu$ PD780058Y subseries is under planning.

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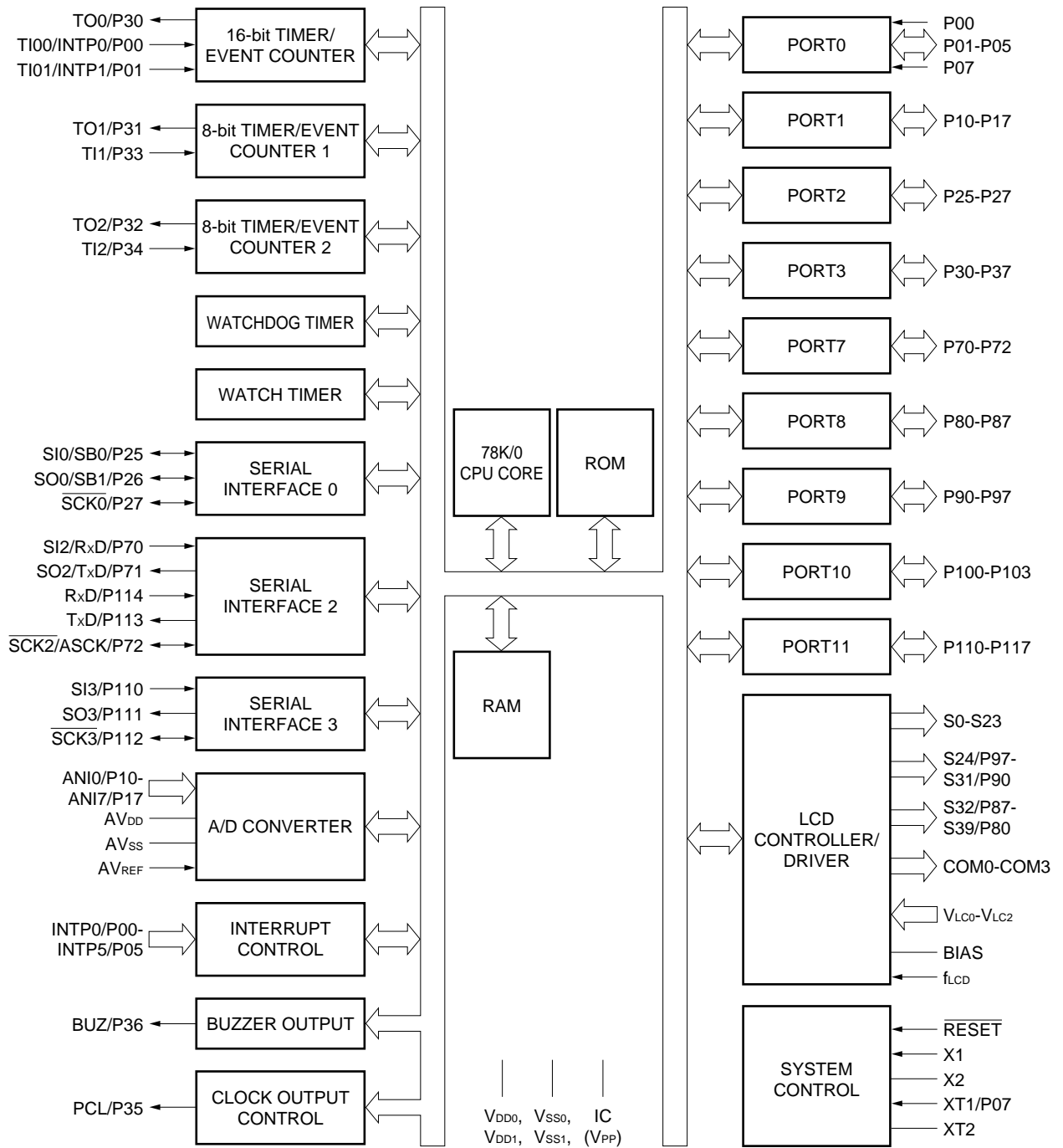
Table 1-12. Functional Outline of  $\mu$ PD780058Y Subseries (2/2)

| Part Number           |              | Item | $\mu$ PD780053Y   | $\mu$ PD780054Y | $\mu$ PD780055Y | $\mu$ PD780056Y | $\mu$ PD780058Y | $\mu$ PD78F0058Y |
|-----------------------|--------------|------|---|-----------------|-----------------|-----------------|-----------------|------------------|
| Buzzer output         |              |      | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)  |                 |                 |                 |                 |                  |
| Vectored interrupt    | Maskable     |      | Internal: 13, external: 7   |                 |                 |                 |                 |                  |
|                       | Non-maskable |      | Internal: 1   |                 |                 |                 |                 |                  |
|                       | Software     |      | 1   |                 |                 |                 |                 |                  |
| Test input            |              |      | Internal: 1, external: 1  |                 |                 |                 |                 |                  |
| Supply voltage        |              |      | $V_{DD} = 1.8$ to $5.5$ V   |                 |                 |                 |                 |                  |
| Operating temperature |              |      | $T_A = -40$ to $+85$ °C   |                 |                 |                 |                 |                  |
| Package               |              |      | <ul style="list-style-type: none"> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 2.7 mm)</li> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 1.4 mm)</li> <li>• 80-pin plastic TQFP (fine pitch) (<math>12 \times 12</math> mm)</li> </ul> |                 |                 |                 |                 |                  |

**Caution** The  $\mu$ PD780058Y subseries is under planning.



Figure 1-13. Block Diagram of  $\mu$ PD780308 Subseries



Remarks 1. The internal ROM capacity differs depending on the model.

2. ( ):  $\mu$ PD78P0308

Table 1-13. Functional Outline of  $\mu$ PD780308 Subseries

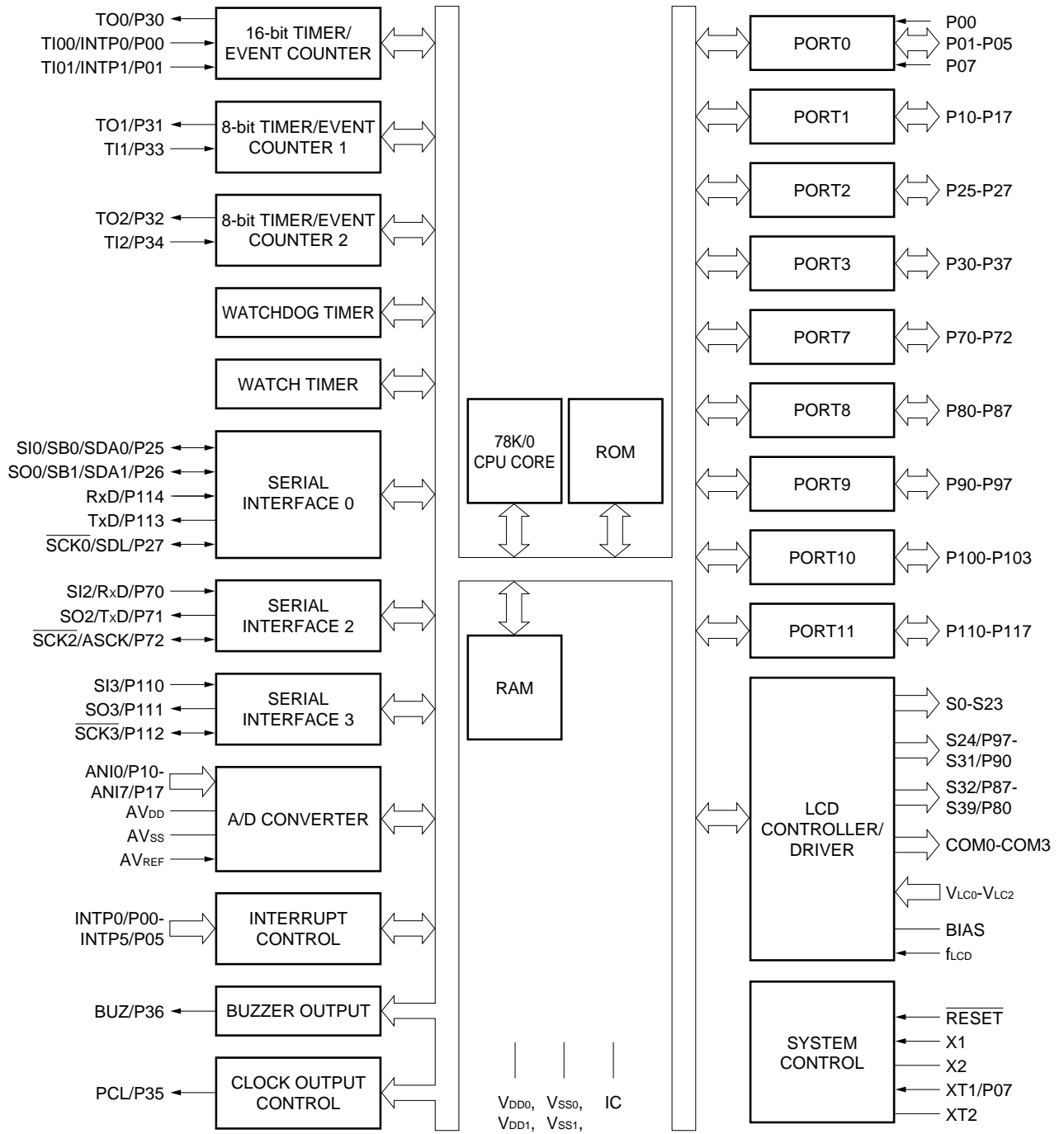
| Part Number  |                        | Item  | $\mu$ PD780306 | $\mu$ PD780308 | $\mu$ PD78P0308           |
|--|------------------------|---|----------------|----------------|---------------------------|
| Internal memory  | ROM                    | Mask ROM  |                |                | PROM                      |
|  |                        | 48K bytes   | 48K bytes      | 60K bytes      | 60K bytes <sup>Note</sup> |
|  | High-speed RAM         | 1024 bytes  |                |                |                           |
|  | Expansion RAM          | 1024 bytes  |                |                |                           |
|  | LCD display RAM        | 40 × 4 bits   |                |                |                           |
| Memory space   |                        | 64K bytes   |                |                |                           |
| General-purpose register   |                        | 8 bits × 8 × 4 banks  |                |                |                           |
| Minimum instruction execution time                               | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)   |                |                |                           |
|  | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)   |                |                |                           |
| Instruction set  |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits × 8 bits, 16 bits ÷ 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul> |                |                |                           |
| I/O port (including pins multiplexed with segment signal output) |                        | <ul style="list-style-type: none"> <li>• Total : 57</li> <li>• CMOS input: 2</li> <li>• CMOS I/O : 55</li> </ul>  |                |                |                           |
| A/D converter  |                        | 8-bit resolution × 8 channels   |                |                |                           |
| LCD controller/driver  |                        | <ul style="list-style-type: none"> <li>• Segment signal output : 40 max.</li> <li>• Common signal output : 4 max.</li> <li>• Bias : 1/2 or 1/3 bias selectable</li> </ul>   |                |                |                           |
| Serial interface   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode : 1 channel</li> </ul>           |                |                |                           |
| Timer  |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>                         |                |                |                           |
| Timer output   |                        | 3 (14-bit PWM output: 1)  |                |                |                           |
| Clock output   |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)  |                |                |                           |
| Buzzer output  |                        | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)  |                |                |                           |
| Vectored interrupt   | Maskable               | Internal: 13, external: 6   |                |                |                           |
|  | Non-maskable           | Internal: 1   |                |                |                           |
|  | Software               | 1   |                |                |                           |
| Test input   |                        | Internal: 1, external: 1  |                |                |                           |
| Supply voltage   |                        | $V_{DD} = 2.0$ to 5.5 V   |                |                |                           |
| Package  |                        | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (fine pitch) (14 × 14 mm)</li> <li>• 100-pin plastic QFP (14 × 20 mm)</li> <li>• 100-pin ceramic WQFN (14 × 20 mm) (<math>\mu</math>PD78P0308 only)</li> </ul>                   |                |                |                           |

**Note** The capacity of the internal PROM can be changed by using a memory size select register (IMS).

**Caution** The  $\mu$ PD780308 subseries is under development.

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Figure 1-14. Block Diagram of  $\mu$ PD780308Y Subseries



Remarks 1. The internal ROM capacity differs depending on the model.

2. ( ):  $\mu$ PD78P0308Y



**Table 1-14. Functional Outline of  $\mu$ PD780308Y Subseries**

| Part Number  |                        | $\mu$ PD780306Y  | $\mu$ PD780308Y | $\mu$ PD78P0308Y          |
|--|------------------------|--|-----------------|---------------------------|
| Internal memory  | ROM                    | Mask ROM   |                 | PROM                      |
|  |                        | 48K bytes  | 60K bytes       | 60K bytes <sup>Note</sup> |
|  | High-speed RAM         | 1024 bytes   |                 |                           |
|  | Expansion RAM          | 1024 bytes   |                 |                           |
|  | LCD display RAM        | 40 × 4 bits  |                 |                           |
| Memory space   |                        | 64K bytes  |                 |                           |
| General-purpose register   |                        | 8 bits × 8 × 4 banks   |                 |                           |
| Minimum Instruction execution cycle                              | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)  |                 |                           |
|  | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)  |                 |                           |
| Instruction set  |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits × 8 bits, 16 bits ÷ 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>      |                 |                           |
| I/O port (including pins multiplexed with segment signal output) |                        | <ul style="list-style-type: none"> <li>• Total : 57</li> <li>• CMOS input: 2</li> <li>• CMOS I/O : 55</li> </ul>   |                 |                           |
| A/D converter  |                        | 8-bit resolution × 8 channels  |                 |                           |
| LCD controller/driver  |                        | <ul style="list-style-type: none"> <li>• Segment signal output : 40 max.</li> <li>• Common signal output : 4 max.</li> <li>• Bias : 1/2 or 1/3 bias selectable</li> </ul>  |                 |                           |
| Serial interface   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/2-wire serial I/O/I<sup>2</sup>C bus mode selectable : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode : 1 channel</li> </ul> |                 |                           |
| Timer  |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>                              |                 |                           |
| Timer output   |                        | 3 (14-bit PWM output: 1)   |                 |                           |
| Clock output   |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)   |                 |                           |
| Buzzer output  |                        | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)   |                 |                           |
| Vectored interrupt source  | Maskable               | Internal: 13, external: 6  |                 |                           |
|  | Non-maskable           | Internal: 1  |                 |                           |
|  | Software               | 1  |                 |                           |
| Test input   |                        | Internal: 1, external: 1   |                 |                           |
| Supply voltage   |                        | V <sub>DD</sub> = 2.0 to 5.5 V   |                 |                           |
| Package  |                        | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (14 × 20 mm)</li> <li>• 100-pin ceramic WQFN (14 × 20 mm) (<math>\mu</math>PD78P0308Y only)</li> </ul>  |                 |                           |

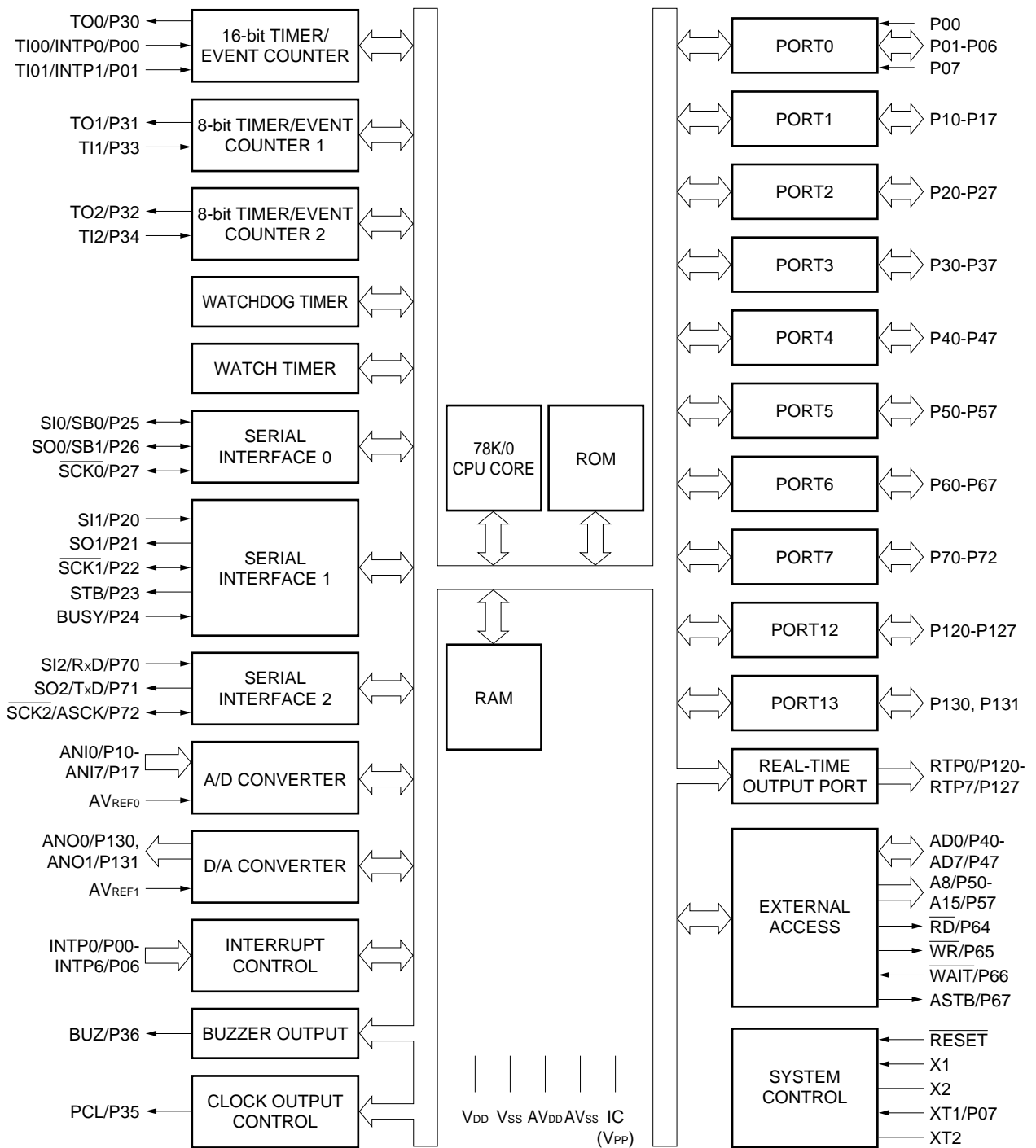
**Note** The capacity of the internal PROM can be changed by using a memory size select register (IMS).

**Caution** The  $\mu$ PD780308Y subseries is under development.





Figure 1-15. Block Diagram of  $\mu$ PD78058F Subseries



**Remarks 1.** The internal ROM and RAM capacities differ depending on the model.

**2.** ( ):  $\mu$ PD78P058F

Table 1-15. Functional Outline of  $\mu$ PD78058F Subseries (1/2)

| Part Number                        |                        | Item   | $\mu$ PD78056F | $\mu$ PD78058F               | $\mu$ PD78P058F             |
|------------------------------------|------------------------|--|----------------|------------------------------|-----------------------------|
| Internal memory                    | ROM                    | Mask ROM   |                |                              | PROM                        |
|                                    |                        | 48K bytes  |                | 60K bytes                    | 60K bytes <sup>Note 1</sup> |
|                                    | High-speed RAM         | 1024 bytes   |                |                              |                             |
|                                    | Buffer RAM             | 32 bytes   |                |                              |                             |
|                                    | Expansion RAM          | None   | 1024 bytes     | 1024 bytes <sup>Note 2</sup> |                             |
| Memory space                       |                        | 64K bytes  |                |                              |                             |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks   |                |                              |                             |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)  |                |                              |                             |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)  |                |                              |                             |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>                      |                |                              |                             |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 69</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 63</li> <li>• N-ch open-drain I/O : 4</li> </ul>   |                |                              |                             |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels   |                |                              |                             |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels   |                |                              |                             |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul> |                |                              |                             |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>  |                |                              |                             |
| Timer output                       |                        | 3 (14-bit PWM output: 1)   |                |                              |                             |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)   |                |                              |                             |

**Notes 1.** The capacity of the internal PROM can be changed by using a memory size select register (IMS).

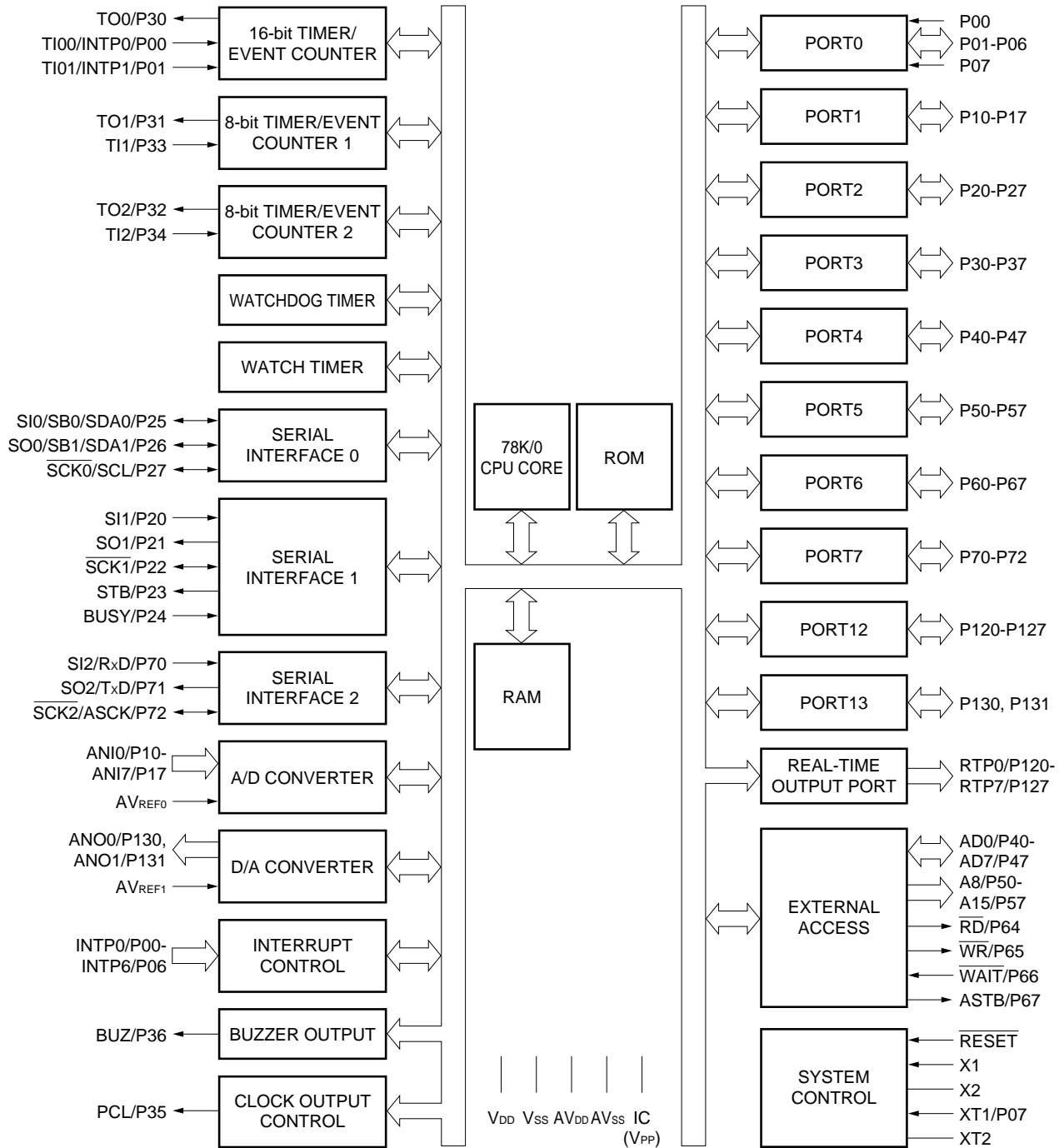
**2.** The internal expansion RAM capacity can be changed by using an internal expansion RAM size select register (IXS).

Table 1-15. Functional Outline of  $\mu$ PD78058F Subseries (2/2)

| Part Number               |              | $\mu$ PD78056F   | $\mu$ PD78058F | $\mu$ PD78P058F |
|---------------------------|--------------|--|----------------|-----------------|
| Buzzer output             |              | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)   |                |                 |
| Vectored interrupt source | Maskable     | Internal: 13, external: 7  |                |                 |
|                           | Non-maskable | Internal: 1  |                |                 |
|                           | Software     | Internal: 1  |                |                 |
| Test input                |              | Internal: 1, external: 1   |                |                 |
| Supply voltage            |              | $V_{DD} = 2.7$ to $6.0$ V  |                |                 |
| Package                   |              | <ul style="list-style-type: none"> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 2.7 mm)</li> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 1.4 mm)<sup>Note</sup></li> <li>• 80-pin plastic TQFP (fine pitch) (<math>12 \times 12</math> mm) (<math>\mu</math>PD78058F only)</li> </ul> |                |                 |

**Note** Under planning

Figure 1-16. Block Diagram of  $\mu$ PD78058FY Subseries



**Remarks 1.** The capacities of the internal ROM and RAM differ depending on the model.

**2.** ( ):  $\mu$ PD78P058FY

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Table 1-16. Functional Outline of  $\mu$ PD78058FY Subseries (1/2)

| Part Number                        |                        | $\mu$ PD78056FY   | $\mu$ PD78058FY | $\mu$ PD78P058FY             |
|------------------------------------|------------------------|---|-----------------|------------------------------|
| Internal memory                    | ROM                    | Mask ROM  |                 | PROM                         |
|                                    |                        | 48K bytes   | 60K bytes       | 60K bytes <sup>Note 1</sup>  |
|                                    | High-speed RAM         | 1024 bytes  |                 |                              |
|                                    | Buffer RAM             | 32 bytes  |                 |                              |
|                                    | Expansion RAM          | None  | 1024 bytes      | 1024 bytes <sup>Note 2</sup> |
| Memory space                       |                        | 64K bytes   |                 |                              |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks  |                 |                              |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)   |                 |                              |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)   |                 |                              |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>                                     |                 |                              |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 69</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 63</li> <li>• N-ch open-drain I/O : 4</li> </ul>  |                 |                              |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels  |                 |                              |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels  |                 |                              |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/2-wire serial I/O/I<sup>2</sup>C bus mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul> |                 |                              |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>   |                 |                              |
| Timer output                       |                        | 3 (14-bit PWM output: 1)  |                 |                              |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)  |                 |                              |

- Notes**
1. The capacity of the internal PROM can be changed by using a memory size select register (IMS).
  2. The internal expansion RAM capacity can be changed by using an internal expansion RAM size select register (IXS).

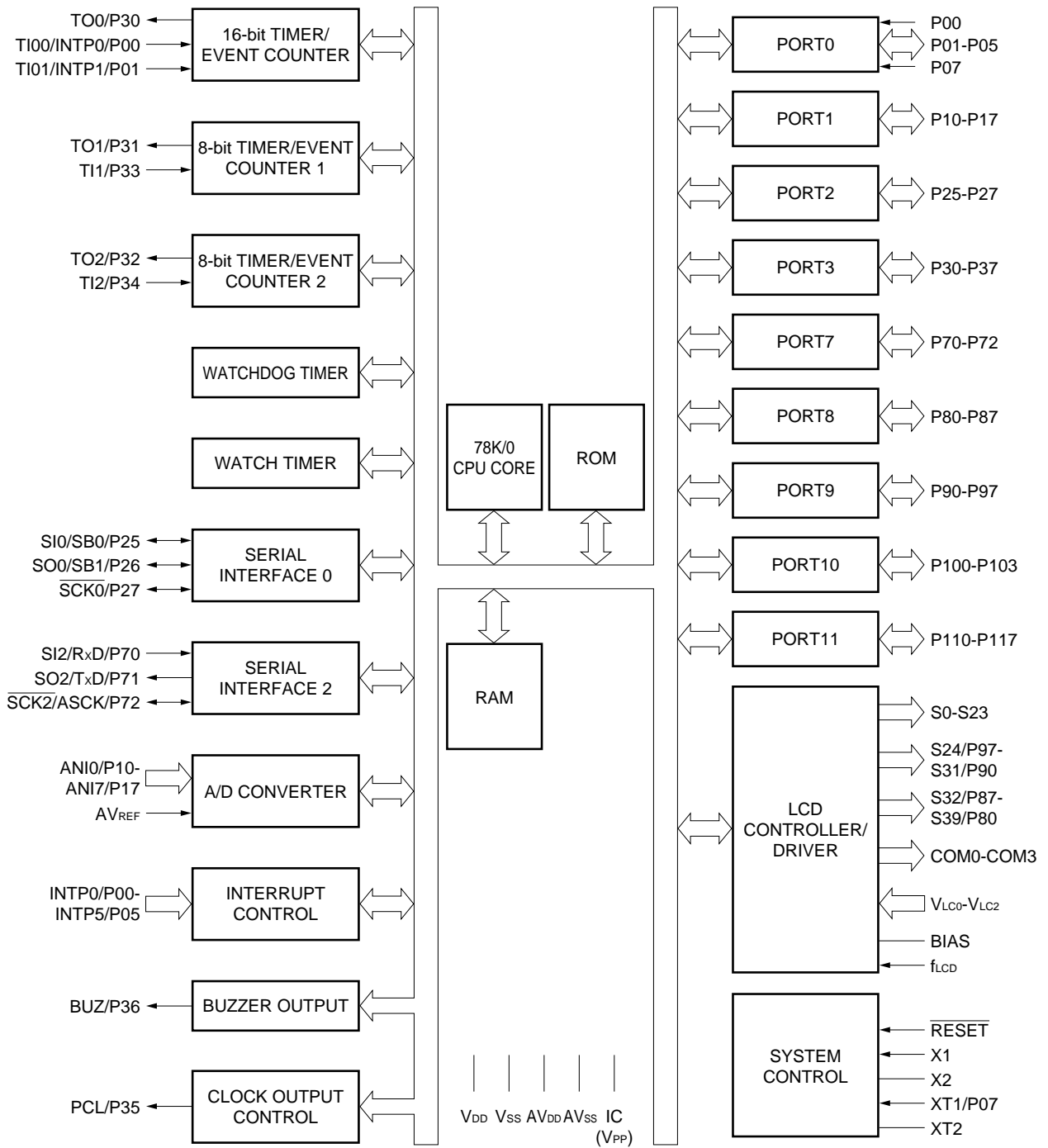
**Table 1-16. Functional Outline of  $\mu$ PD78058FY Subseries (2/2)**

| Part Number               |              | Item | $\mu$ PD78056FY  | $\mu$ PD78058FY | $\mu$ PD78P058FY |
|---------------------------|--------------|------|--|-----------------|------------------|
| Buzzer output             |              |      | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)   |                 |                  |
| Vectored interrupt source | Maskable     |      | Internal: 13, external: 7  |                 |                  |
|                           | Non-maskable |      | Internal: 1  |                 |                  |
|                           | Software     |      | 1  |                 |                  |
| Test input                |              |      | Internal: 1, external: 1   |                 |                  |
| Supply voltage            |              |      | $V_{DD} = 2.7$ to $6.0$ V  |                 |                  |
| Package                   |              |      | <ul style="list-style-type: none"> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 2.7 mm)</li> <li>• 80-pin plastic QFP (<math>14 \times 14</math> mm, resin thickness 1.4 mm)<sup>Note</sup></li> <li>• 80-pin plastic TQFP (fine pitch)(<math>12 \times 12</math> mm) (<math>\mu</math>PD78058FY only)</li> </ul> |                 |                  |

**Note** Under planning

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Figure 1-17. Block Diagram of  $\mu$ PD78064B Subseries



Remark ( ):  $\mu$ PD78P064B



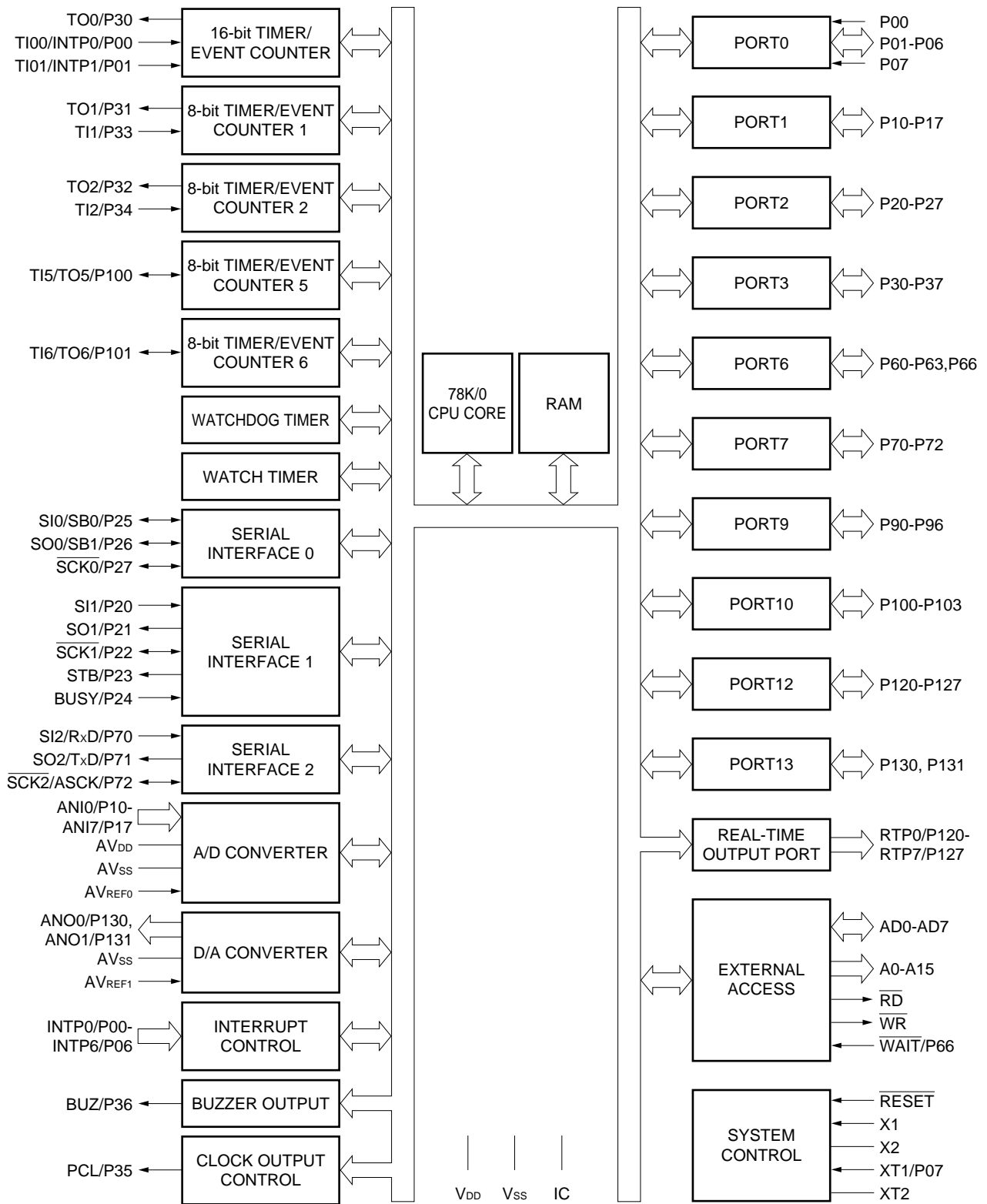
**Table 1-17. Functional Outline of  $\mu$ PD78064B Subseries**

| Part Number  |                        | Item        | $\mu$ PD78064B  | $\mu$ PD78P064B |
|--|------------------------|-------------|---|-----------------|
| Internal memory  | ROM                    | Mask ROM    |   | PROM            |
|  |                        | 32K bytes   |   |                 |
|  | High-speed RAM         | 1024 bytes  |   |                 |
|  | LCD display RAM        | 40 × 4 bits |   |                 |
| Memory space   |                        |             | 64K bytes   |                 |
| General-purpose register   |                        |             | 8 bits × 8 × 4 banks  |                 |
| Minimum instruction execution time                               | With main system clock |             | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)   |                 |
|  | With subsystem clock   |             | 122 $\mu$ s (at 32.768 kHz)   |                 |
| Instruction set  |                        |             | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits × 8 bits, 16 bits ÷ 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul> |                 |
| I/O port (including pins multiplexed with segment signal output) |                        |             | <ul style="list-style-type: none"> <li>• Total : 57</li> <li>• CMOS input: 2</li> <li>• CMOS I/O : 55</li> </ul>  |                 |
| A/D converter  |                        |             | 8-bit resolution × 8 channels   |                 |
| LCD controller/driver  |                        |             | <ul style="list-style-type: none"> <li>• Segment signal output : 40 max.</li> <li>• Common signal output : 4 max.</li> <li>• Bias : 1/2 or 1/3 bias selectable</li> </ul>   |                 |
| Serial interface   |                        |             | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul>   |                 |
| Timer  |                        |             | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>                         |                 |
| Timer output   |                        |             | 3 (14-bit PWM output: 1)  |                 |
| Clock output   |                        |             | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)  |                 |
| Buzzer output  |                        |             | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)  |                 |
| Vectored interrupt source  | Maskable               |             | Internal: 12, external: 6   |                 |
|  | Non-maskable           |             | Internal: 1   |                 |
|  | Software               |             | 1   |                 |
| Test input   |                        |             | Internal: 1, external: 1  |                 |
| Supply voltage   |                        |             | $V_{DD} = 2.0$ to $6.0$ V   |                 |
| Package  |                        |             | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (fine pitch) (14 × 14 mm)</li> <li>• 100-pin plastic QFP (14 × 20 mm)</li> </ul>   |                 |



★

Figure 1-18. Block Diagram of  $\mu$ PD78070A



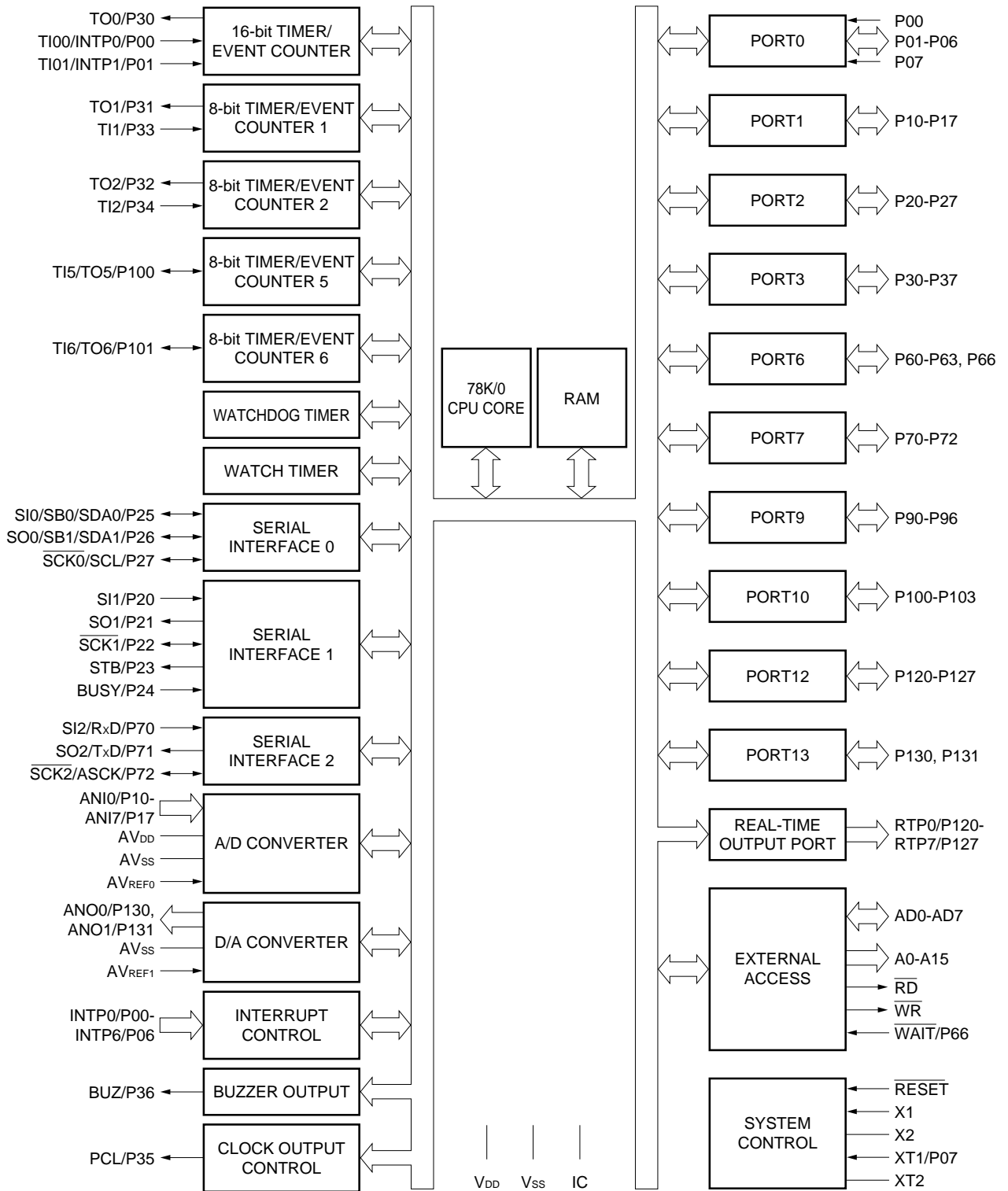
★

Table 1-18. Functional Outline of  $\mu$ PD78070A

| Part Number                        |                        | Functions  |
|------------------------------------|------------------------|--|
| Internal memory                    | ROM                    | None   |
|                                    | High-speed RAM         | 1024 bytes   |
|                                    | Buffer RAM             | 32 bytes   |
| Memory space                       |                        | 64K bytes  |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks   |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)  |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)  |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>                      |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 61</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 51</li> <li>• N-ch open-drain I/O : 8</li> </ul>   |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels   |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels   |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul> |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 4 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>  |
| Timer output                       |                        | 5 (14-bit PWM output: 1, 8-bit PWM output: 2)  |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)   |
| Vectored interrupt source          | Maskable               | Internal: 15, external: 7  |
|                                    | Non-maskable           | Internal: 1  |
|                                    | Software               | 1  |
| Test input                         |                        | Internal: 1  |
| Supply voltage                     |                        | $V_{DD} = 2.7$ to 5.5 V  |
| Package                            |                        | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (fine pitch) (14 <math>\times</math> 14 mm)</li> <li>• 100-pin plastic QFP (14 <math>\times</math> 20 mm)</li> </ul>  |



Figure 1-19. Block Diagram of  $\mu$ PD78070AY

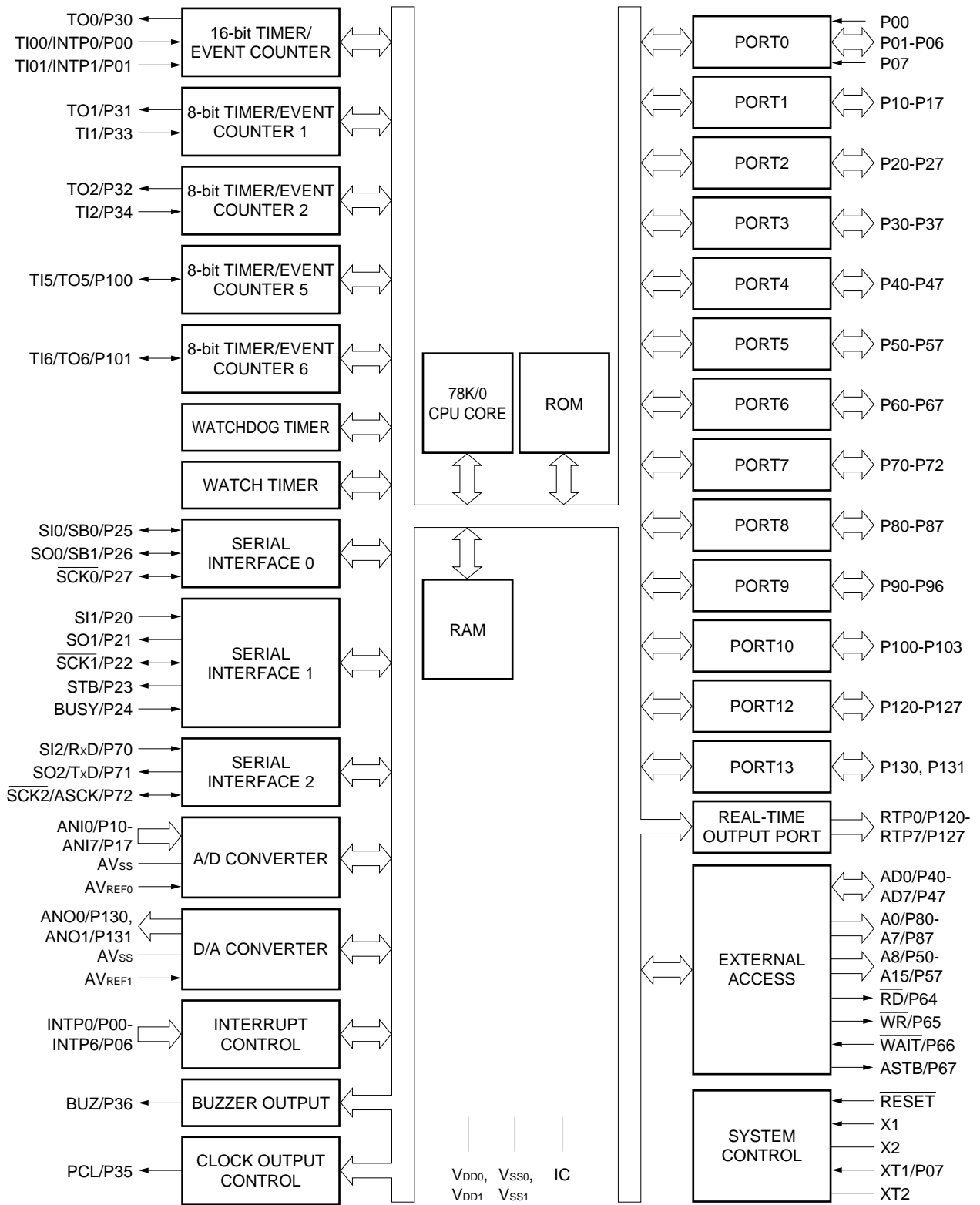


★ **Table 1-19. Functional Outline of  $\mu$ PD78070AY**

| Part Number                        |                        | Functions   |
|------------------------------------|------------------------|---|
| Internal memory                    | ROM                    | None  |
|                                    | High-speed RAM         | 1024 bytes  |
|                                    | Buffer RAM             | 32 bytes  |
| Memory space                       |                        | 64K bytes   |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks  |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)   |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)   |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>                                     |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 61</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 51</li> <li>• N-ch open-drain I/O : 8</li> </ul>  |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels  |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels  |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/2-wire serial I/O/I<sup>2</sup>C bus mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul> |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 4 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>   |
| Timer output                       |                        | 5 (14-bit PWM output: 1, 8-bit PWM output: 2)   |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)  |
| Buzzer output                      |                        | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)  |
| Vectored interrupt source          | Maskable               | Internal: 15, external: 7   |
|                                    | Non-maskable           | Internal: 1   |
|                                    | Software               | 1   |
| Test input                         |                        | Internal: 1   |
| Supply voltage                     |                        | V <sub>DD</sub> = 2.7 to 5.5 V  |
| Package                            |                        | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (14 <math>\times</math> 20 mm)</li> <li>• 100-pin plastic QFP (fine pitch) (14 <math>\times</math> 14 mm)</li> </ul>   |

★

Figure 1-20. Block Diagram of  $\mu$ PD78075B Subseries



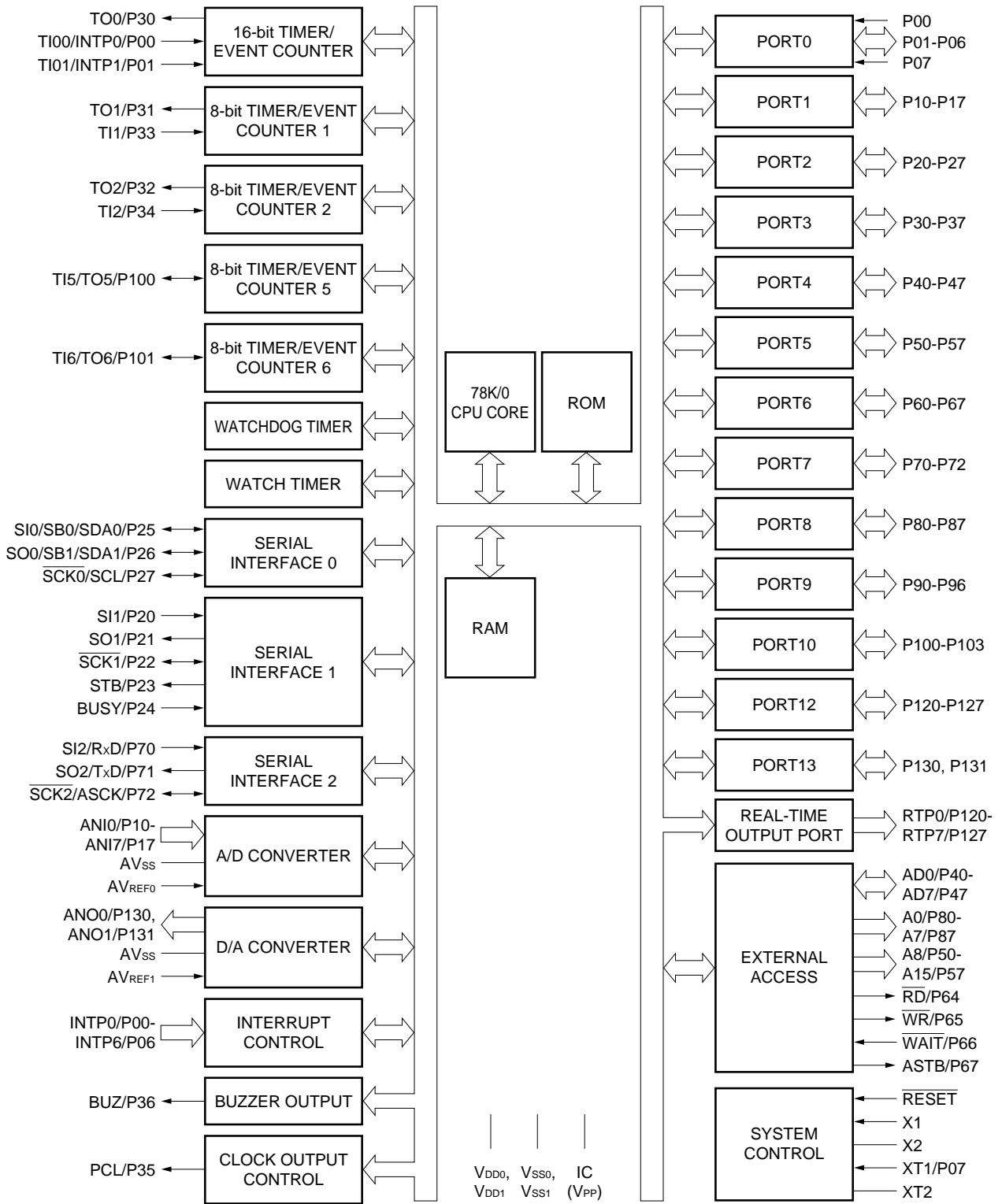
**Remark** The internal ROM capacity differs depending on the model.

★ **Table 1-20. Functional Outline of  $\mu$ PD78075B8 Subseries**

| Part Number                        |                        | Item   | $\mu$ PD78074B | $\mu$ PD78075B |
|------------------------------------|------------------------|--|----------------|----------------|
| Internal memory                    | ROM                    | Mask ROM   |                |                |
|                                    | High-speed RAM         | 32K bytes  | 40K bytes      |                |
|                                    | Buffer RAM             | 1024 bytes   |                |                |
|                                    | Expansion RAM          | 32 bytes   |                |                |
| Memory space                       |                        | 64K bytes  |                |                |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks   |                |                |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)  |                |                |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)  |                |                |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>                      |                |                |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 88</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 78</li> <li>• N-ch open-drain I/O : 8</li> </ul>   |                |                |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels   |                |                |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels   |                |                |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul> |                |                |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 4 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>  |                |                |
| Timer output                       |                        | 5 (14-bit PWM output: 1, 8-bit PWM output: 2)  |                |                |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)   |                |                |
| Vectored interrupt source          | Maskable               | Internal: 15, external: 7  |                |                |
|                                    | Non-maskable           | Internal: 1  |                |                |
|                                    | Software               | 1  |                |                |
| Test input                         |                        | Internal: 1, external: 1   |                |                |
| Supply voltage                     |                        | $V_{DD} = 1.8$ to 5.5 V  |                |                |
| Package                            |                        | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (fine pitch) (14 <math>\times</math> 14 mm, resin thickness 1.45 mm)</li> <li>• 100-pin plastic QFP (14 <math>\times</math> 20 mm, resin thickness 2.7 mm)</li> </ul>   |                |                |



Figure 1-21. Block Diagram of  $\mu$ PD78075BY Subseries



**Remark** The internal ROM capacity differs depending on the model.



**Table 1-21. Functional Outline of  $\mu$ PD78075BY Subseries**

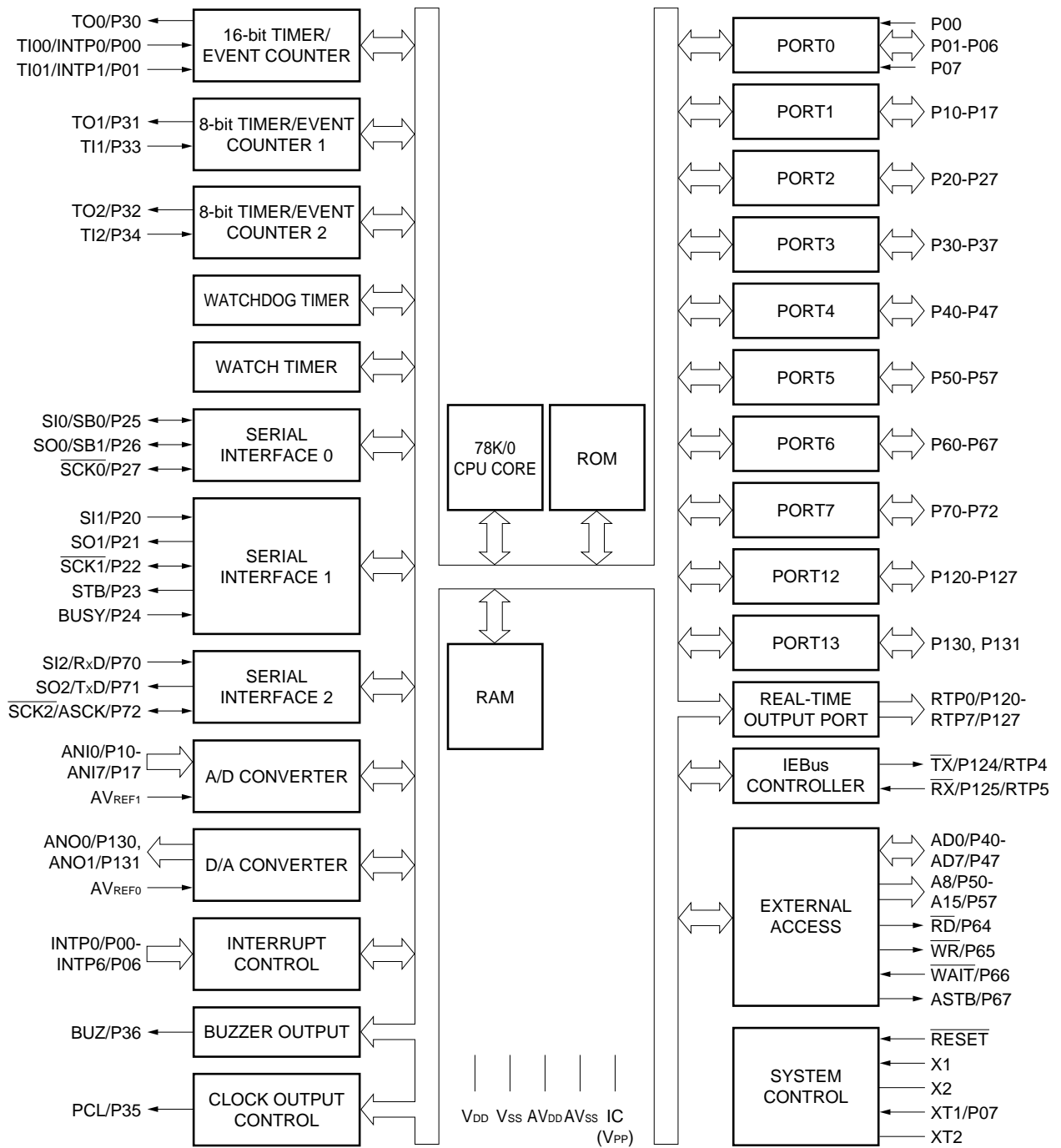
| Part Number                        |                        | $\mu$ PD78074BY   | $\mu$ PD78075BY |
|------------------------------------|------------------------|---|-----------------|
| Internal memory                    | ROM                    | Mask ROM  |                 |
|                                    |                        | 32K bytes   | 40K bytes       |
|                                    | High-speed RAM         | 1024 bytes  |                 |
|                                    | Buffer RAM             | 32 bytes  |                 |
| Memory space                       |                        | 64K bytes   |                 |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks  |                 |
| Minimum instruction execution time | With main system clock | 0.4 $\mu$ s/0.8 $\mu$ s/1.6 $\mu$ s/3.2 $\mu$ s/6.4 $\mu$ s/12.8 $\mu$ s (at 5.0 MHz)   |                 |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)   |                 |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>                                     |                 |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 88</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 78</li> <li>• N-ch open-drain I/O : 8</li> </ul>  |                 |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels  |                 |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels  |                 |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/2-wire serial I/O/I<sup>2</sup>C bus mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul> |                 |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 4 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>   |                 |
| Timer output                       |                        | 5 (14-bit PWM output: 1, 8-bit PWM output: 2)   |                 |
| Clock output                       |                        | 19.5 kHz, 39.1 kHz, 78.1 kHz, 156 kHz, 313 kHz, 625 kHz, 1.25 MHz, 2.5 MHz, 5.0 MHz (with main system clock of 5.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)  |                 |
| Buzzer output                      |                        | 1.2 kHz, 2.4 kHz, 4.9 kHz, 9.8 kHz (with main system clock of 5.0 MHz)  |                 |
| Vectored interrupt source          | Maskable               | Internal: 15, external: 7   |                 |
|                                    | Non-maskable           | Internal: 1   |                 |
|                                    | Software               | 1   |                 |
| Test input                         |                        | Internal: 1, external: 1  |                 |
| Supply voltage                     |                        | $V_{DD} = 1.8$ to 5.5 V   |                 |
| Package                            |                        | <ul style="list-style-type: none"> <li>• 100-pin plastic QFP (14 <math>\times</math> 20 mm, resin thickness 2.7 mm)</li> </ul>  |                 |

**Caution** The  $\mu$ PD78075BY subseries is under development.



★

Figure 1-22. Block Diagram of  $\mu$ PD78098B Subseries



**Remarks 1.** The internal ROM and RAM capacities differ depending on the model.

**2.** ( ):  $\mu$ PD78P098B

Table 1-22. Functional Outline of  $\mu$ PD78098B Subseries

| Part Number                        |                        | $\mu$ PD78095B   | $\mu$ PD78096B | $\mu$ PD78098B | $\mu$ PD78P098B              |
|------------------------------------|------------------------|--|----------------|----------------|------------------------------|
| Internal memory                    | ROM                    | Mask ROM   |                |                | PROM                         |
|                                    |                        | 40K bytes  | 48K bytes      | 60K bytes      | 60K bytes <sup>Note 1</sup>  |
|                                    | High-speed RAM         | 1024 bytes   |                |                |                              |
|                                    | Buffer RAM             | 32 bytes   |                |                |                              |
|                                    | Expansion RAM          | None   |                | 2048 bytes     | 2048 bytes <sup>Note 2</sup> |
| Memory space                       |                        | 64K bytes  |                |                |                              |
| General-purpose register           |                        | 8 bits $\times$ 8 $\times$ 4 banks   |                |                |                              |
| Minimum instruction execution time | With main system clock | 0.5 $\mu$ s/1.0 $\mu$ s/2.0 $\mu$ s/4.0 $\mu$ s/8.0 $\mu$ s/16.0 (at 6.0 MHz)  |                |                |                              |
|                                    | With subsystem clock   | 122 $\mu$ s (at 32.768 kHz)  |                |                |                              |
| Instruction set                    |                        | <ul style="list-style-type: none"> <li>• 16-bit operation</li> <li>• Multiplication/division (8 bits <math>\times</math> 8 bits, 16 bits <math>\div</math> 8 bits)</li> <li>• Bit manipulation (set, reset, test, Boolean operation)</li> <li>• BCD adjustment, etc.</li> </ul>                      |                |                |                              |
| I/O port                           |                        | <ul style="list-style-type: none"> <li>• Total : 69</li> <li>• CMOS input : 2</li> <li>• CMOS I/O : 63</li> <li>• N-ch open-drain I/O: 4</li> </ul>  |                |                |                              |
| IEBus controller                   |                        | Effective transfer rate: 3.9 kbps/17 kbps/26 kbps  |                |                |                              |
| A/D converter                      |                        | 8-bit resolution $\times$ 8 channels   |                |                |                              |
| D/A converter                      |                        | 8-bit resolution $\times$ 2 channels   |                |                |                              |
| Serial interface                   |                        | <ul style="list-style-type: none"> <li>• 3-wire serial I/O/SBI/2-wire serial I/O mode selectable : 1 channel</li> <li>• 3-wire serial I/O mode (with function to automatically transfer/receive up to 32 bytes) : 1 channel</li> <li>• 3-wire serial I/O/UART mode selectable : 1 channel</li> </ul> |                |                |                              |
| Timer                              |                        | <ul style="list-style-type: none"> <li>• 16-bit timer/event counter : 1 channel</li> <li>• 8-bit timer/event counter : 2 channels</li> <li>• Watch timer : 1 channel</li> <li>• Watchdog timer : 1 channel</li> </ul>  |                |                |                              |
| Timer output                       |                        | 3 (14-bit PWM output: 1)   |                |                |                              |
| Clock output                       |                        | 15.6 kHz, 31.3 kHz, 62.5 kHz, 125 kHz, 250 kHz, 500 kHz, 1.0 MHz, 2.0 MHz, 4.0 MHz (with main system clock of 6.0 MHz), 32.768 kHz (with subsystem clock of 32.768 kHz)  |                |                |                              |
| Buzzer output                      |                        | 977 Hz, 1.95 kHz, 3.9 kHz, 7.8 kHz (with main system clock of 6.0 MHz)   |                |                |                              |
| Vectored interrupt source          | Maskable               | Internal: 14, external: 7  |                |                |                              |
|                                    | Non-maskable           | Internal: 1  |                |                |                              |
|                                    | Software               | 1  |                |                |                              |
| Test input                         |                        | Internal: 1, external: 1   |                |                |                              |
| Supply voltage                     |                        | $V_{DD} = 2.7$ to 6.0 V  |                |                |                              |
| Package                            |                        | <ul style="list-style-type: none"> <li>• 80-pin plastic QFP (14 <math>\times</math> 14 mm)</li> <li>• 80-pin ceramic WQFN (14 <math>\times</math> 14 mm) (<math>\mu</math>PD78P098B only)</li> </ul>   |                |                |                              |

**Notes 1.** The internal PROM capacity can be changed by using a memory size select register (IMS).

**2.** The internal expansion RAM can be changed by using an internal expansion RAM size select register (IXS).

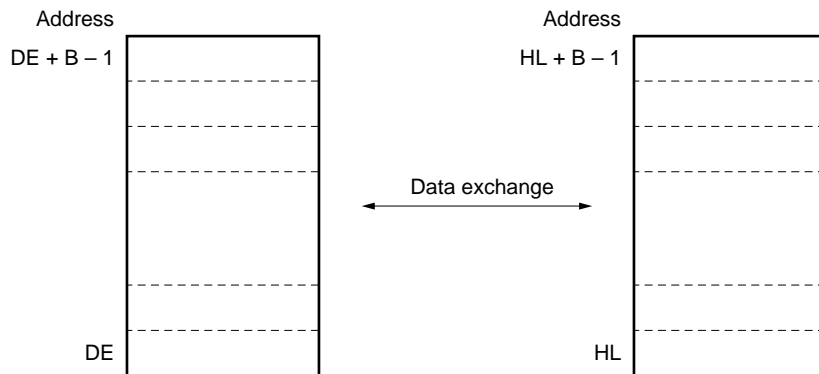
**Caution** The  $\mu$ PD78098B subseries is under planning.

## CHAPTER 2 FUNDAMENTALS OF SOFTWARE

### 2.1 Data Transfer

Data is exchanged by using an address specified by the DE and HL registers as the first address. The number of bytes of the data to be exchanged is specified by the B register.

**Figure 2-1. Data Exchange**



**(1) Registers used**

A, B, DE, HL

**(2) Program list**

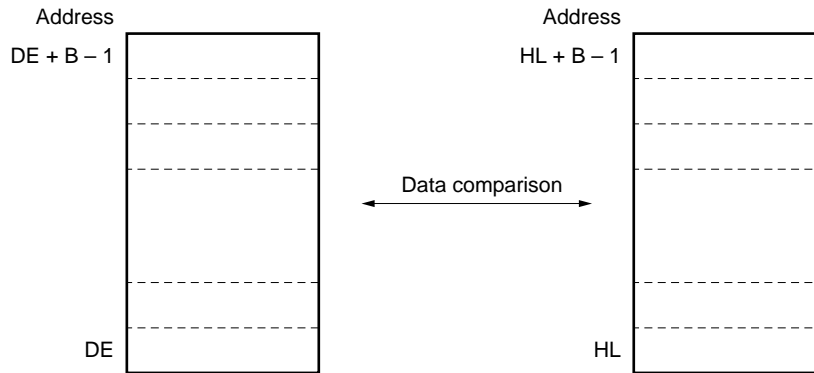
EXCH:

```
MOV    A,[DE]
XCH    A,[HL]
XCH    A,[DE]
INCW   DE
INCW   HL
DBNZ   B,$EXCH
RET
```

## 2.2 Data Comparison

Data is compared by using an address specified by the DE and HL registers as the first address. The number of bytes of the data to be compared is specified by the B register. If the result of comparison is equal, CY is cleared to 0; if not, CY is set to 1.

Figure 2-2. Data Comparison



### (1) Registers used

A, B, DE, HL

### (2) Program list

COMP:

```

MOV    A,[DE]
CMP    A,[HL]
BNZ    $ERROR
INCW   DE
INCW   HL
DBNZ   B,$COMP
CLR1   CY
BR     RTN

```

ERROR:

```

SET1   CY

```

RTN:

```

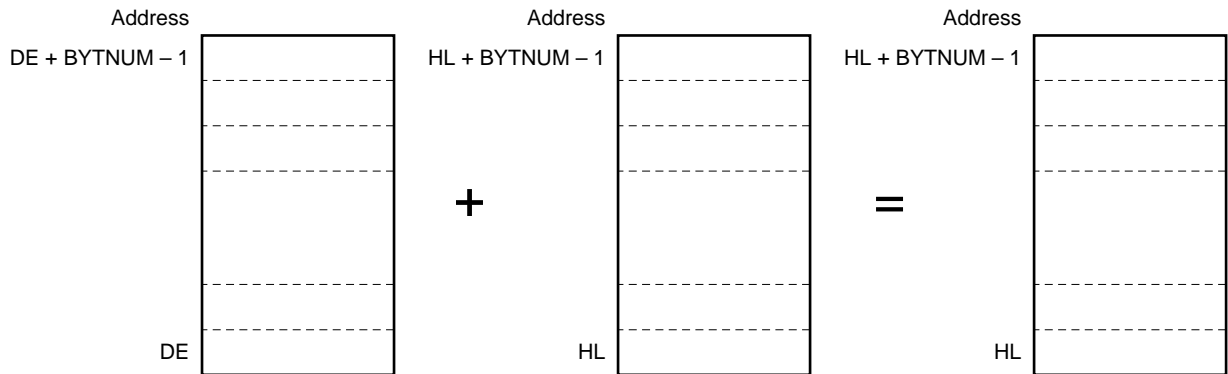
RET

```

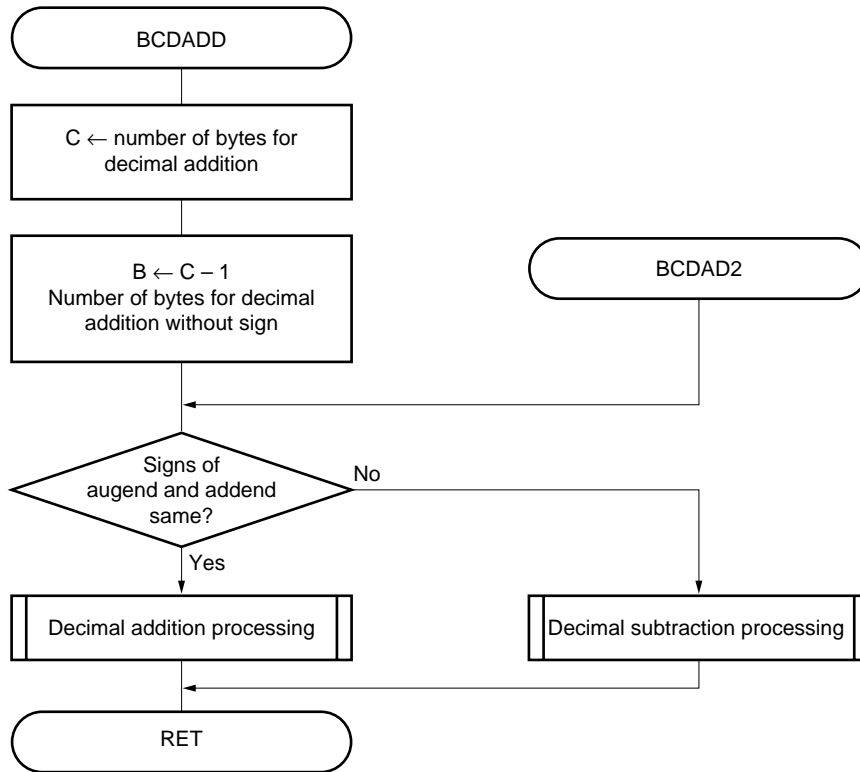
### 2.3 Decimal Addition

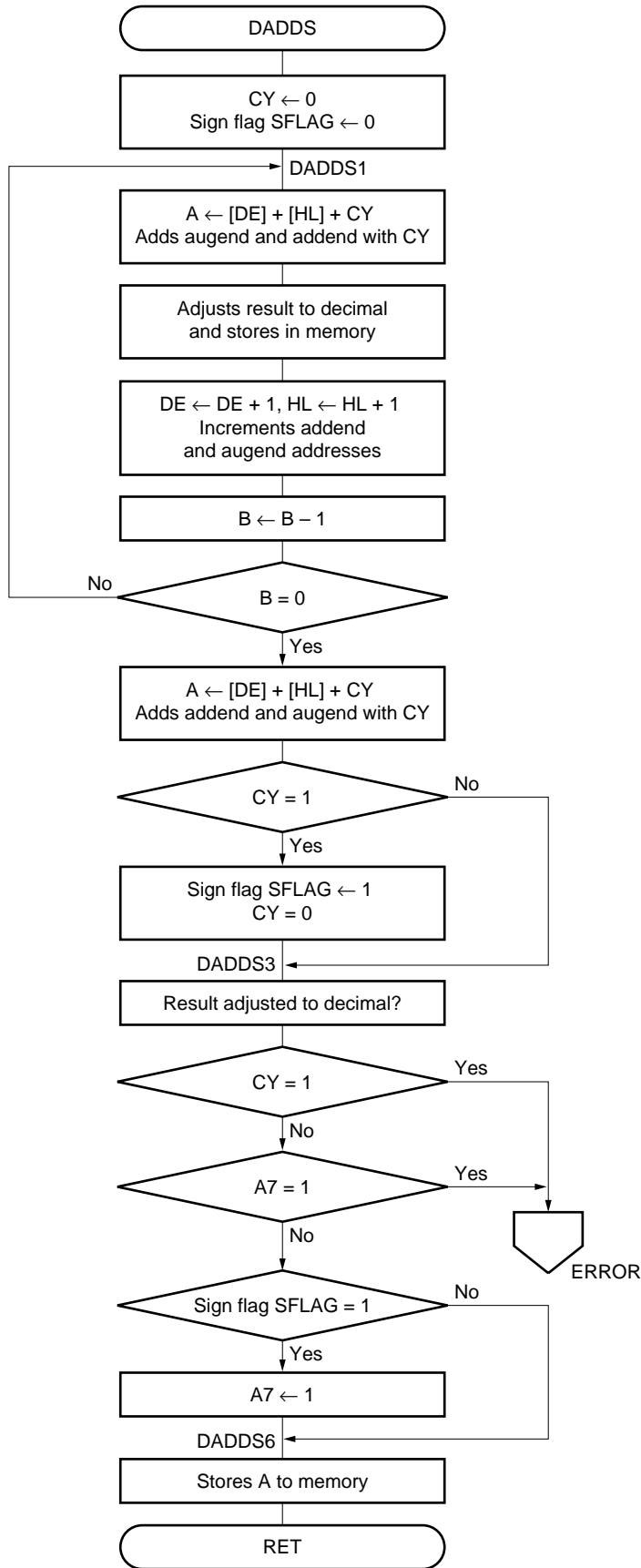
The lowest address for decimal addition is specified by the DE and HL registers, and the number of digits specified by BYTNUM is added. The result of the addition is stored to an area specified by the HL register. If an overflow or underflow occurs as a result of the addition, execution branches to error processing. Define the branch address as 'ERROR' in the main routine. Also declare it as PUBLIC.

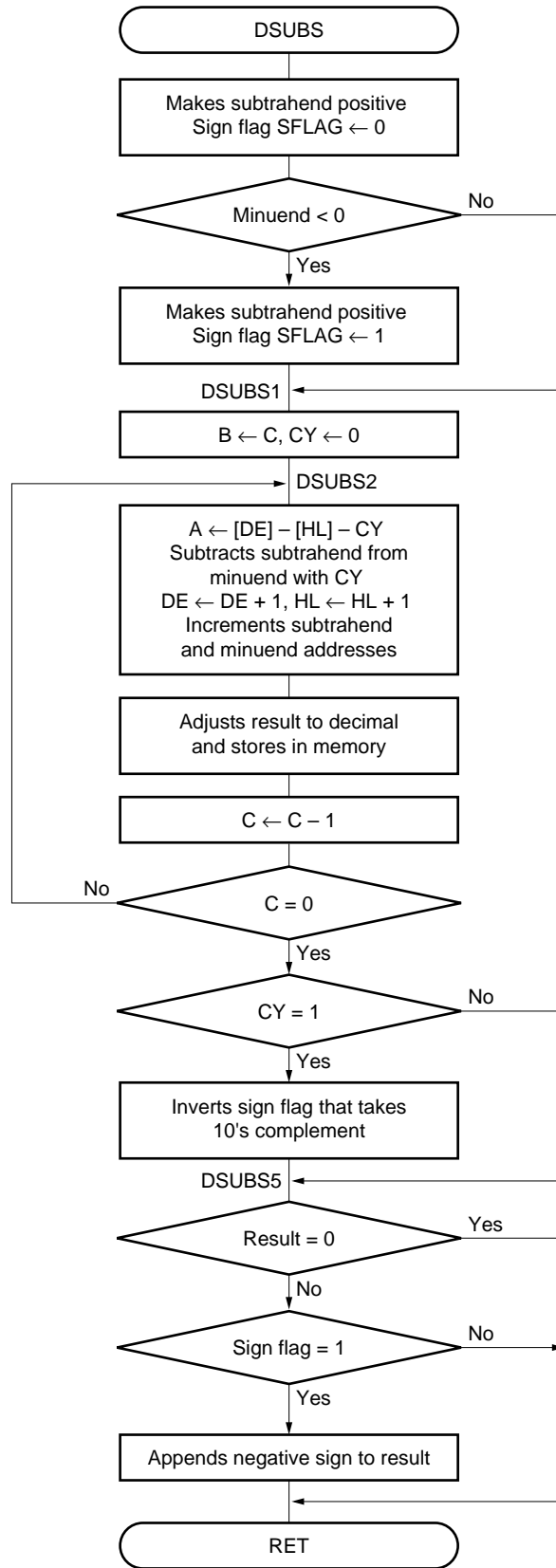
Figure 2-3. Decimal Addition



(1) Flowchart







(2) Registers used

AX, BC, DE, HL

(3) Program list

```

;*****
;
;   Input parameter
;       HL register: addend first address
;       DE register: augend first address
;   Output parameter
;       HL register: Operation result first address
;*****

PUBLIC BCDADD,BCDAD1,BCDAD2
PUBLIC DADDS
PUBLIC DSUBS
EXTRN  ERROR                ; Error processing branch address
EXTBIT SFLAG                ; Sign flag
;
BYTNUM EQU 4                ; Sets number of digits for operation
;
CSEG
BCDADD:
MOV     C,#BYTNUM           ; Sets number of digits for operation to C register
BCDAD1:
MOV     A,C
MOV     B,A
DEC     B
BCDAD2:
MOV     A,[HL+BYTNUM-1]    ; Loads MSB (sign data) of augend
XCHW   AX,DE
XCHW   AX,HL
XCHW   AX,DE
XOR     A,[HL+BYTNUM-1]    ; Loads MSB (sign data) of augend
XCHW   AX,HL
XCHW   AX,DE
XCHW   AX,HL

BT     A.7,$BCDAD3         ; Signs coincide? ELSE subtraction processing
CALL   !DADDS              ; THEN addition processing
RET
BCDAD3:
CALL   !DSUBS
RET

```



```

;=====
;          ***** 10 Decimal addition *****
;=====

DADDS:
    CLR1    CY
    CLR1    SFLAG
DADDS1:
    MOV     A, [DE]                ; Starts addition from lowest digit
    ADDC   A, [HL]
    ADJBA
    MOV     [HL], A
    INCW   HL
    INCW   DE
    DBNZ   B, $DADDS1             ; End of addition (number of digits for operation - 1)

    MOV     A, [DE]
    ADDC   A, [HL]
DADDS2:
    BNC    $DADDS3                ; Negative addition
    SET1   SFLAG                  ; THEN sets negative status
    CLR1   CY
DADDS3:
    ADJBA
    BNC    $DADDS4
    BR     ERROR
DADDS4:
    BF     A.7, $DADDS5
    BR     ERROR
DADDS5:
    BF     SFLAG, $DADDS6         ; Sets sign
    SET1   A.7
DADDS6:
    MOV     [HL], A
    RET

```

```

;=====
;          ***** 10 Decimal subtraction *****
;=====

DSUBS:
    PUSH    HL
    CLR1    SFLAG
    MOV     A, [HL+BYTNUM-1]      ; Sets subtrahend as positive value
    CLR1    A.7
    MOV     [HL+BYTNUM-1], A
    XCHW   AX, DE
    XCHW   AX, HL
    XCHW   AX, DE
    MOV     A, [HL+BYTNUM-1]
    BF     A.7, $DSUBS1          ; Minuend is negative
    CLR1    A.7                  ; THEN sets minuend as positive value
    MOV     [HL+BYTNUM-1], A
    SET1    SFLAG                ; Sets sign as negative

DSUBS1:
    XCHW   AX, HL
    XCHW   AX, DE
    XCHW   AX, HL
    MOV     A, C
    MOV     B, A
    CLR1    CY

DSUBS2:
    MOV     A, [DE]
    SUBC   A, [HL]
    ADJBS
    MOV     [HL], A
    INCW   HL
    INCW   DE
    DBNZ   C, $DSUBS2           ; End of subtraction of number of digits for operation

    BNC    $DSUBS5              ; THEN subtrahend > minuend
    POP    HL
    PUSH   HL
    MOV    A, B
    MOV    C, A

DSUBS3:
    MOV     A, #99H              ; Complement operation of result of subtraction
    SUB     A, [HL]              ; (result of subtraction - 99H)
    ADJBS
    MOV     [HL], A
    INCW   HL
    DBNZ   C, $DSUBS3

    POP    HL
    PUSH   HL
    SET1   CY

    MOV    A, B
    MOV    C, A

DSUBS4:
    MOV     A, #0                ; Adds 1 to result of complement operation
    ADDC   A, [HL]
    ADJBA

```

```

MOV    [HL],A
INCW  HL
DBNZ  C,$DSUBS4
MOV1  CY,SFLAG
NOT1  CY
MOV1  SFLAG,CY
;=====
;    ***** 0 check of operation result *****
;=====

DSUBS5:
MOV    A,B
MOV    C,A
POP    HL
PUSH  HL
MOV    A,#0

DSUBS6:
CMP    A,[HL]                ; 0 check from lowest digit
INCW  HL
BNZ    $DSUBS7
DBNZ  C,$DSUBS6              ; 0 check of all digits completed
POP    HL                    ; THEN result of subtraction = 0
RET

DSUBS7:
BF     SFLAG,$DSUBS8         ; Result of subtraction is negative
POP    HL                    ; THEN sets sign
PUSH  HL
MOV    A,[HL+BYTNUM-1]
SET1  A.7
MOV    [HL+BYTNUM-1],A

DSUBS8:
POP    HL
RET

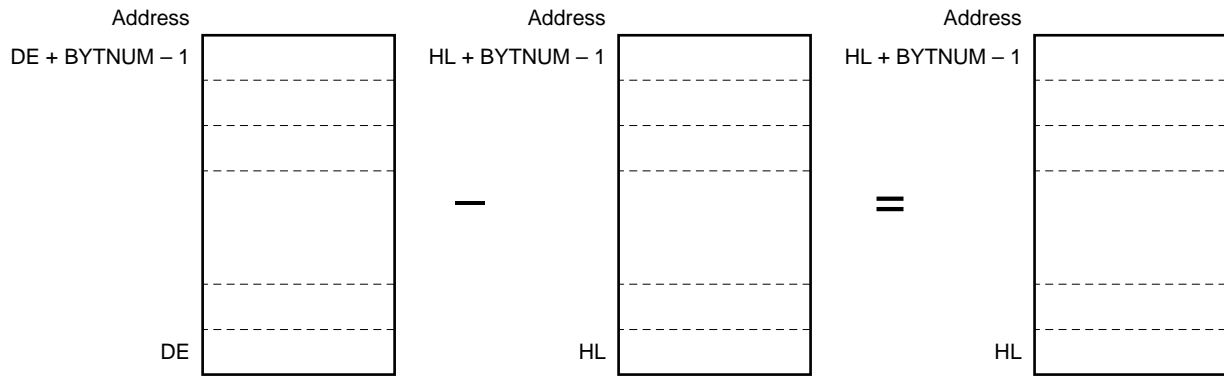
```

## 2.4 Decimal Subtraction

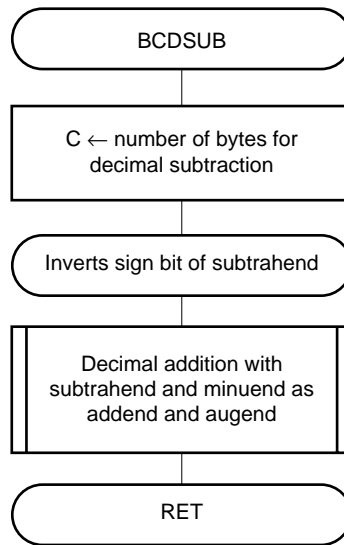
The lowest address for decimal subtraction is specified by the DE and HL registers, and the number of digits specified by BYTNUM is subtracted. The result of the subtraction is stored to an area specified by the HL register. If an overflow or underflow occurs as a result of the subtraction, execution branches to error processing. Define the branch address as 'ERROR' in the main routine. Also declare it as PUBLIC.

This program replaces minuend and subtrahend with augend and addend, and calls a program of decimal addition.

Figure 2-4. Decimal Subtraction



### (1) Flowchart



### (2) Registers used

AX, BC, DE, HL

## (3) Program list

```

;*****
;
;      Input parameter
;          HL register: subtrahend first address
;          DE register: minuend first address
;      Output parameter
;          HL register: Operation result first address
;
;*****

        PUBLIC BYTNUM
        PUBLIC BCDSUB
        EXTRN  BCDADD,BCDAD2

;
BYTNUM EQU    4                ; Sets number of digits for operation
;
        CSEG
BCDSUB:
        MOV    C, #BYTNUM      ; Sets number of digits for operation to C register
BCDSU1:
        MOV    A, C
        MOV    B, A
        DEC   B

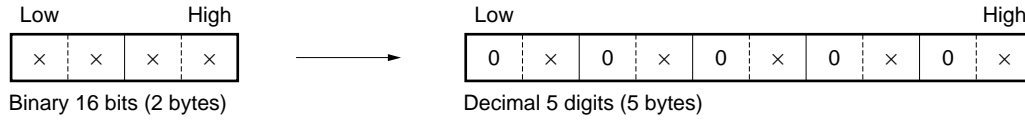
        MOV    A, [HL+BYTNUM-1] ; Sets MSB (sign data) of subtrahend for addition
        MOV1  CY, A.7           ; Inverts sign data
        NOT1  CY
        MOV1  A.7, CY
        MOV   [HL+BYTNUM-1], A
        CALL  !BCDAD2          ; Calls decimal addition processing
        RET

```

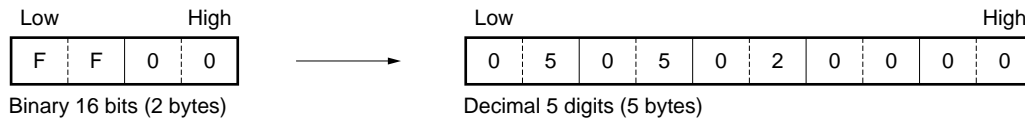
## 2.5 Binary-to-Decimal Conversion

Binary data of 16 bits in data memory is converted into 5-digit decimal data and stored in data memory. Binary data of 16 bits is divided by decimal 10 by the number of times equal to the number of digits (4 times), and conversion is carried out with the result of the operation and the value of the remainder at that time.

**Figure 2-5. Binary-to-Decimal Conversion**



**Example** To convert FFH into decimal number



**(1) Registers used**

AX, BC, HL

**(2) Program list**

```
        PUBLIC B_DCONV
        DATDEC EQU    10

        DSEG    SADDRP
REGA:   DS      2          ; Stores binary 16-bit data
REGB:   DS      5          ; Stores decimal 5-digit data

        COLNUM EQU    4

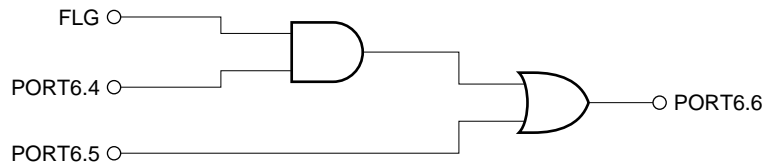
B_DCONV:
        MOVW    AX,REGA
        MOV     B,#COLNUM
        MOVW    HL,#REGB

B_D1:
        MOV     C,#DATDEC
        DIVUW   C
        XCH    A,C
        MOV    [HL],A
        INCW   HL
        XCH    A,C
        DBNZ   B,$B_D1
        MOV    A,X
        MOV    [HL],A
        RET
```

## 2.6 Bit Manipulation Instruction

A 1 bit of a flag in the data memory is ANDed with the bit 4 of port 6, and the result is ANDed with the bit 5 of port 6 and is output to the bit 6 of port 6.

Figure 2-6. Bit Operation



### (1) Program list

```

PUBLIC BIT_OP,FLG

BSEG
FLG DBIT

BIT_OP:
MOV1 CY,FLG
AND1 CY,P6.4
OR1 CY,P6.5
MOV1 P6.6,CY
RET

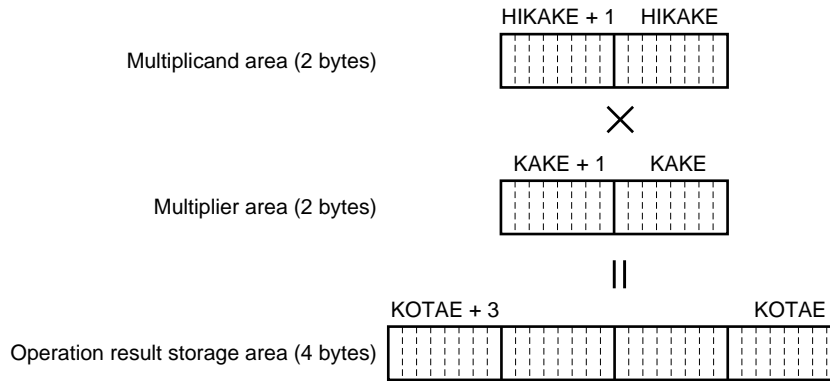
```



## 2.7 Binary Multiplication (16 bits × 16 bits)

Data in a multiplicand area (HIKAKE; 16 bits) and multiplier area (KAKE; 16 bits) are multiplied, and the result is stored in an operation result storage area (KOTAE).

Figure 2-7. Binary Multiplication



### <Processing contents>

Multiplication is performed by adding the multiplicand by the number of bits of the multiplier that are "1".

**<Contents used>**

Set the data in the multiplicand (HIKAKE) and multiplier (KAKE) areas, and call subroutine S\_KAKERU.

```

        EXTRN  S_KAKERU
        EXTRN  HIKAKE, KAKE, KOTAE
MAIN:
        .
        .
        HIKAKE=WORKA (A) ; Stores multiplicand data to multiplicand area
        HIKAKE+1=WORKA+1 (A) ;
        KAKE=WORKB (A) ; Stores multiplier data to multiplier area
        KAKE+1=WORKB+1 (A) ;
        CALL  !S_KAKERU ; Calls multiplication routine
        HL=#KOTAE ; HL ← RAM address of operation result storage area
        . ; Stores result by indirect address transfer
        .
        .

```

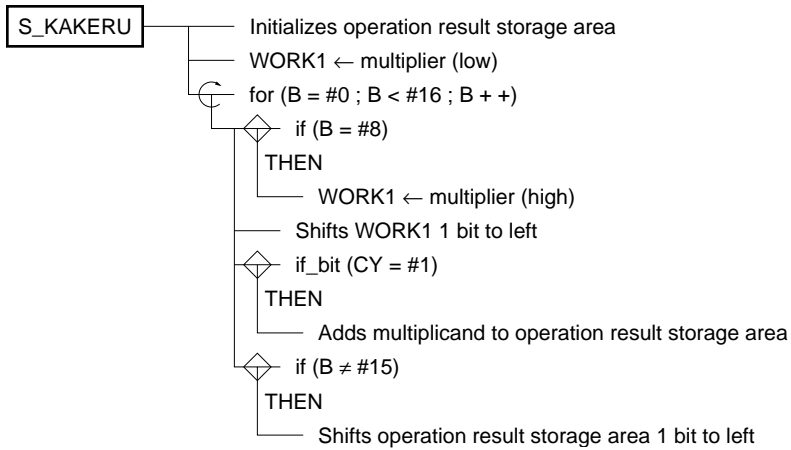
**Caution** Manipulate the data memory in 8-bit units.

**(1) Input/output condition**

- Input parameter  
 HIKAKE : Store the multiplicand data in this area.  
 KAKE : Store the multiplier data in this area.
- Output parameter  
 KOTAE: Store the result of the operation in this area.

**(2) SPD chart**

**[Multiplication subroutine]**



**(3) Registers used**

A, B

## (4) Program list

```

$PC(054)
;
PUBLIC HIKAKE,S_KAKERU,KAKE,KOTAE
;
;*****
;          RAM definition
;*****
          DSEG      SADDR
HIKAKE:   DS        2                ; Multiplicand area
KAKE:     DS        2                ; Multiplier area
WORK1:    DS        1                ; Work area
KOTAE:    DS        4                ; Operation result storage area
;
;*****
;          Multiplication
;*****
          CSEG
S_KAKERU:
          WORK1=KAKE+1 (A)           ; Stores multiplier (low) in work area
          KOTAE=#0                   ; Initializes operation result storage area
          KOTAE+1=#0                 ;
          KOTAE+2=#0                 ;
          KOTAE+3=#0                 ;
          for (B=#0;B<#16;B++) (A)   ; Stores higher multiplier in work area
            if (B == #8) (A)         ; if low multiplication is completed
              WORK1=KAKE (A)         ;
              endif                 ;
              A=WORK1                ; Shifts multiplier 1 bit to left
              CLR1 CY                 ;
              ROLC A,1               ;
              WORK1=A                ;
              if_bit(CY)             ; Adds multiplicand to operation
                KOTAE+=HIKAKE (A)    ; result storage area if carry occurs
                (KOTAE+1)+=HIKAKE+1,CY (A) ;
                (KOTAE+2)+=#0,CY (A) ;
                (KOTAE+3)+=#0,CY (A) ;
              endif                 ;
            if (B != #15) (A)        ; Shifts operation result storage area 1 bit to left
              KOTAE+=KOTAE (A)       ;
              KOTAE+1+=KOTAE+1,CY (A) ;
              KOTAE+2+=KOTAE+2,CY (A) ;
              KOTAE+3+=KOTAE+3,CY (A) ;
            endif                 ;
          next                       ;
          RET                         ;
          END

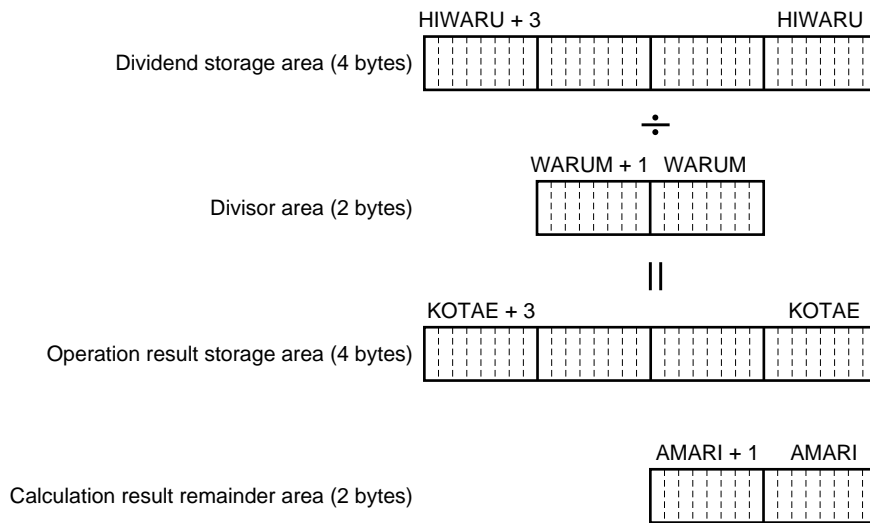
```

### 2.8 Binary Division (32 bits ÷ 16 bits)

Data in a dividend area (HIWARU; 32 bits) is divided by data in a divisor area (WARUM; 16 bits), and the result is stored in an operation result storage area (KOTAE). If a remainder is generated, it is stored in a calculation result remainder area (AMARI).

If division is executed with the divisor being 0, an error occurs.

Figure 2-8. Binary Division



**<Processing contents>**

The dividend is shifted to the left to the work area starting from the highest digit. If the contents of the work area are greater than the divisor, the divisor is subtracted from the work area, and the least significant bit of the dividend is set to 1. In this way, division is carried out by executing the program by the number of bits of the dividend.

If the divisor is 0, an error flag (F\_ERR) is set.

**<Usage>**

Set data in the dividend area (HIWARU) and divisor area (WARUM), and call subroutine S\_WARU.

```
EXTRN  S_WARU
EXTRN  HIWARU,WARUM,KOTAE
EXBIT  F_ERR

MAIN:
        .
        .
        HIWARU=WORKA (A)          ; Stores dividend data to dividend area
        HIWARU+1=WORKA+1 (A)      ;
        WARUM=WORKB (A)          ; Stores divisor data to divisor area
        WARUM+1=WORKB+1 (A)      ;
        CALL  !S_WARU             ; Calls division calculation routine
        HL=#KOTAE                ; HL ← stores RAM address of operation result storage area
        .
        .
        if_bit(F_ERR)            ;
        Calculation error processing ;
        endif                    ;
        .
        .
        .
```

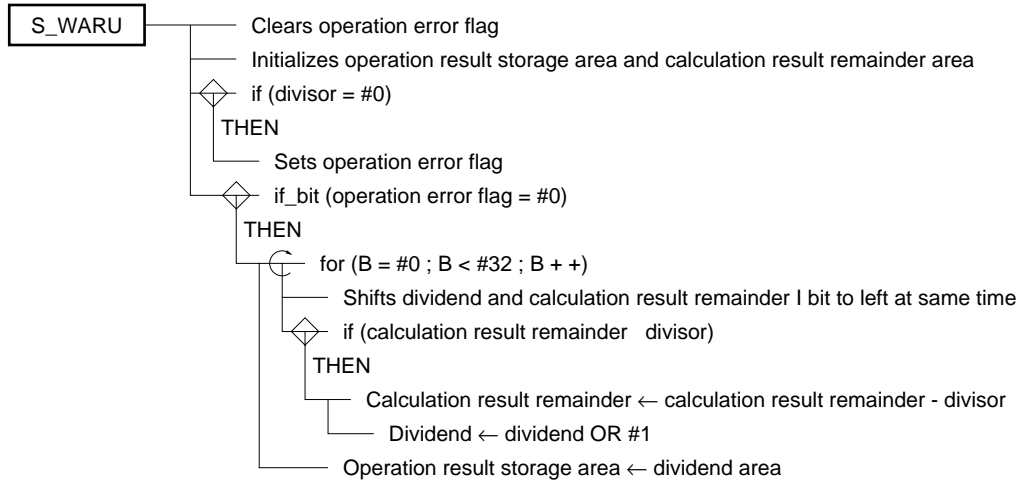
**Caution** Manipulate the data memory in 8-bit units.

**(1) Input/output conditions**

- Input parameter  
 HIWARU: Store the dividend data in this area.  
 WARUM : Store the divisor data in this area.
- Output parameter  
 KOTAE : Store the result of the calculation in this area.

**(2) SPD chart**

**[Division subroutine]**



**(3) Registers used**

A, B

## (4) Program list

```

$PC(054)
;
PUBLIC S_WARU,HIWARU,WARUM,F_ERR
EXTRN KOTAE
;
;*****
;          RAM definition
;*****
          DSEG      SADDR
HIWARU:   DS        4          ; Dividend area
WARUM:    DS        2          ; Divisor area
AMARI:    DS        2          ; Calculation result remainder storage area
          BSEG
F_ERR     DBIT          ; Operation error flag
;*****
;          Division
;*****
          CSEG          ;
S_WARU:   ;
          CLR1          F_ERR          ; Clears operation error flag
          AMARI=#0      ; Clears calculation result storage area to 0
          AMARI+1=#0    ;
          KOTAE=#0      ; Clears operation result storage area to 0
          KOTAE+1=#0    ;
          KOTAE+2=#0    ;
          KOTAE+3=#0    ;
          if(WARUM == #0)          ; Divisor = 0?
              if(WARUM+1 == #0)    ;
                  SET1          F_ERR          ; Sets operation error flag if divisor is 0
              endif
          endif
          if_bit(!F_ERR)          ; Operation error?
              for(B=#0;B < #32;B++) (A)          ; Starts 32-bit division
                  HIWARU+=HIWARU (A)          ; Shifts dividend and remainder 1 bit to left
                  HIWARU+1+=HIWARU+1,CY (A)    ;
                  HIWARU+2+=HIWARU+2,CY (A)    ;
                  HIWARU+3+=HIWARU+3,CY (A)    ;
                  AMARI+=AMARI,CY (A)          ;
                  AMARI+1+=AMARI+1,CY (A)      ;
                  ;
                  if(AMARI+1 > WARUM+1) (A)    ; Remainder ≥ divisor?
                      AMARI-=WARUM (A)        ; Remainder = remainder – divisor
                      AMARI+1-=WARUM+1,CY (A) ;
                      HIWARU |= #1            ; Stores 1 to first bit of dividend area
                  elseif_bit(Z)
                      if(AMARI >= WARUM) (A) ;
                          AMARI-=WARUM(A)    ;
                          AMARI+1-=WARUM+1,CY (A) ;
                          HIWARU |= #1      ;
                      endif
                  endif
              next
              KOTAE=HIWARU (A)          ; Stores operation result
              KOTAE+1=HIWARU+1 (A)      ;
              KOTAE+2=HIWARU+2 (A)      ;
              KOTAE+3=HIWARU+3 (A)      ;
          endif
          RET
          END

```



## CHAPTER 3 APPLICATION OF SYSTEM CLOCK SELECTION

The 78K/0 series allows you to select a CPU clock and controls the operation of the oscillator by rewriting the contents of the processor clock control register (PCC), oscillation mode select register (OSMS), and clock select registers 1 and 2 (IECL1 and IECL2).

When the CPU clock is changed, the time shown in Table 3-1 is required since the contents of the PCC have been rewritten until the CPU clock is actually changed. It is therefore not apparent for a while after the contents of the PCC have been rewritten, whether the processor operates on the new or old clock. To stop the main system clock or execute the STOP instruction, therefore, the wait time shown in Table 3-1 is necessary.

**Caution** IECL1 and IECL2 are provided to the  $\mu$ PD78098, 78098B subseries only.

**Table 3-1. Maximum Time Required for Changing CPU Clock**

| Set Value before Change |     |      |      |      | Set Value after Change   |      |      |      |  |      |      |      |   |      |      |      |   |      |      |      |  |      |      |      |               |   |   |   |
|-------------------------|-----|------|------|------|--|------|------|------|--|------|------|------|---|------|------|------|---|------|------|------|--|------|------|------|---------------|---|---|---|
| MCS                     | CSS | PCC2 | PCC1 | PCC0 | CSS  | PCC2 | PCC1 | PCC0 | CSS  | PCC2 | PCC1 | PCC0 | CSS   | PCC2 | PCC1 | PCC0 | CSS   | PCC2 | PCC1 | PCC0 | CSS  | PCC2 | PCC1 | PCC0 |               |   |   |   |
|                         |     |      |      |      | 0  | 0    | 0    | 0    | 0  | 0    | 0    | 1    | 0   | 0    | 1    | 0    | 0   | 0    | 1    | 1    | 0  | 1    | 0    | 0    | 1             | × | × | × |
| ×                       | 0   | 0    | 0    | 0    | /  |      |      |      | 8 instructions   |      |      |      | 4 instructions  |      |      |      | 2 instructions  |      |      |      | 1 instruction  |      |      |      | 1 instruction |   |   |   |
| ×                       | 0   | 0    | 0    | 1    |  |      |      |      | 16 instructions  |      |      |      | 4 instructions  |      |      |      | 2 instructions  |      |      |      | 1 instruction  |      |      |      | 1 instruction |   |   |   |
| ×                       | 0   | 0    | 1    | 0    |  |      |      |      | 16 instructions  |      |      |      | 8 instructions  |      |      |      | 2 instructions  |      |      |      | 1 instruction  |      |      |      | 1 instruction |   |   |   |
| ×                       | 0   | 0    | 1    | 1    |  |      |      |      | 16 instructions  |      |      |      | 8 instructions  |      |      |      | 4 instructions  |      |      |      | 1 instruction  |      |      |      | 1 instruction |   |   |   |
| ×                       | 0   | 1    | 0    | 0    |  |      |      |      | 16 instructions  |      |      |      | 8 instructions  |      |      |      | 4 instructions  |      |      |      | 2 instructions   |      |      |      | 1 instruction |   |   |   |
| 1                       | 1   | ×    | ×    | ×    | f <sub>x</sub> /2f <sub>XT</sub> instructions<br>(77 instructions) |      |      |      | f <sub>x</sub> /4f <sub>XT</sub> instructions<br>(39 instructions) |      |      |      | f <sub>x</sub> /8f <sub>XT</sub> instructions<br>(20 instructions)  |      |      |      | f <sub>x</sub> /16f <sub>XT</sub> instructions<br>(10 instructions) |      |      |      | f <sub>x</sub> /32f <sub>XT</sub> instructions<br>(5 instructions) |      |      |      | /             |   |   |   |
| 0                       | 1   | ×    | ×    | ×    | f <sub>x</sub> /4f <sub>XT</sub> instructions<br>(39 instructions) |      |      |      | f <sub>x</sub> /8f <sub>XT</sub> instructions<br>(20 instructions) |      |      |      | f <sub>x</sub> /16f <sub>XT</sub> instructions<br>(10 instructions) |      |      |      | f <sub>x</sub> /32f <sub>XT</sub> instructions<br>(5 instructions)  |      |      |      | f <sub>x</sub> /64f <sub>XT</sub> instructions<br>(3 instructions) |      |      |      |               |   |   |   |

**Caution** Do not select dividing the CPU clock (PCC0-PCC2) and changing from the main system clock to subsystem clock (by setting CSS to 0 → 1) at the same time.  
 However, dividing the CPU clock (PCC0-PCC2) can be selected at the same time as changing from the subsystem clock to the main system clock.

**Remarks 1.** One instruction is the minimum instruction execution time of the CPU clock before change.  
**2.** ( ): f<sub>x</sub> = 5.0 MHz, f<sub>XT</sub> = 32.768 kHz

**Figure 3-1. Format of Processor Clock Control Register**

( $\mu$ PD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY subseries,  $\mu$ PD78070A, 78070AY)

| Symbol | 7   | 6   | 5                   | 4    | 3                               | 2         | 1    | 0         | Address | At reset | R/W                  |  |
|--------|-----|---|---------------------|------|---------------------------------|-----------|------|-----------|---------|----------|----------------------|--|
| PCC    | MCC | FRC   | CLS                 | CSS  | 0                               | PCC2      | PCC1 | PCC0      | FFFBH   | 04H      | R/W <sup>Note1</sup> |  |
| R/W    | CSS | PCC2  | PCC1                | PCC0 | Selects CPU clock ( $f_{CPU}$ ) |           |      |           |         |          |                      |  |
|        |     |   |                     |      |                                 | MCS = 1   |      | MCS = 0   |         |          |                      |  |
|        | 0   | 0   | 0                   | 0    | $f_{xx}$                        | $f_x$     |      | $f_x/2$   |         |          |                      |  |
|        |     | 0   | 0                   | 1    | $f_{xx}/2$                      | $f_x/2$   |      | $f_x/2^2$ |         |          |                      |  |
|        |     | 0   | 1                   | 0    | $f_{xx}/2^2$                    | $f_x/2^2$ |      | $f_x/2^3$ |         |          |                      |  |
|        |     | 0   | 1                   | 1    | $f_{xx}/2^3$                    | $f_x/2^3$ |      | $f_x/2^4$ |         |          |                      |  |
|        |     | 1   | 0                   | 0    | $f_{xx}/2^4$                    | $f_x/2^4$ |      | $f_x/2^5$ |         |          |                      |  |
|        | 1   | 0   | 0                   | 0    | $f_{xT}/2$                      |           |      |           |         |          |                      |  |
|        |     | 0   | 0                   | 1    |                                 |           |      |           |         |          |                      |  |
|        |     | 0   | 1                   | 0    |                                 |           |      |           |         |          |                      |  |
|        |     | 0   | 1                   | 1    |                                 |           |      |           |         |          |                      |  |
|        |     | 1   | 0                   | 0    | Setting prohibited              |           |      |           |         |          |                      |  |
|        | R   | CLS   | Status of CPU clock |      |                                 |           |      |           |         |          |                      |  |
|        |     | 0   | Main system clock   |      |                                 |           |      |           |         |          |                      |  |
|        |     | 1   | Subsystem clock     |      |                                 |           |      |           |         |          |                      |  |
| R/W    | FRC | Selects feedback resistor of subsystem clock                |                     |      |                                 |           |      |           |         |          |                      |  |
|        | 0   | Uses internal feedback resistor                             |                     |      |                                 |           |      |           |         |          |                      |  |
|        | 1   | Does not use internal feedback resistor                     |                     |      |                                 |           |      |           |         |          |                      |  |
| R/W    | MCC | Controls oscillation of main system clock <sup>Note 2</sup> |                     |      |                                 |           |      |           |         |          |                      |  |
|        | 0   | Enables oscillation   |                     |      |                                 |           |      |           |         |          |                      |  |
|        | 1   | Stops oscillation   |                     |      |                                 |           |      |           |         |          |                      |  |

**Notes 1.** Bit 5 is a read-only bit.

- 2.** Use MCC to stop the oscillation of the main system clock when the CPU operates on the subsystem clock. Do not use the STOP instruction.

**Caution** Be sure to clear bit 3 to 0.

- Remarks 1.**  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )  
**2.**  $f_x$  : main system clock oscillation frequency  
**3.**  $f_{xT}$  : subsystem clock oscillation frequency  
**4.** MCS: bit 0 of oscillation mode select register (OSMS)

Figure 3-2. Format of Processor Clock Control Register ( $\mu$ PD78083 subseries)

|        |   |   |   |   |   |      |      |      |         |          |     |
|--------|---|---|---|---|---|------|------|------|---------|----------|-----|
| Symbol | 7 | 6 | 5 | 4 | 3 | 2    | 1    | 0    | Address | At reset | R/W |
| PCC    | 0 | 0 | 0 | 0 | 0 | PCC2 | PCC1 | PCC0 | FFFBH   | 04H      | R/W |

| PCC2   | PCC1 | PCC0 | Selects CPU clock ( $f_{CPU}$ ) |           |           |
|--------|------|------|---------------------------------|-----------|-----------|
|        |      |      |                                 | MCS = 1   | MCS = 0   |
| 0      | 0    | 0    | $f_{xx}$                        | $f_x$     | $f_x/2$   |
| 0      | 0    | 1    | $f_{xx}/2$                      | $f_x/2$   | $f_x/2^2$ |
| 0      | 1    | 0    | $f_{xx}/2^2$                    | $f_x/2^2$ | $f_x/2^3$ |
| 0      | 1    | 1    | $f_{xx}/2^3$                    | $f_x/2^3$ | $f_x/2^4$ |
| 1      | 0    | 0    | $f_{xx}/2^4$                    | $f_x/2^4$ | $f_x/2^5$ |
| Others |      |      | Setting prohibited              |           |           |

**Caution** Be sure to clear bits 3 through 7 to 0.

- Remarks**
1.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  2.  $f_x$  : main system clock oscillation frequency
  3. MCS: bit 0 of oscillation mode select register (OSMS)

Figure 3-3. Format of Processor Clock Control Register ( $\mu$ PD78098, 78098B subseries)

| Symbol | 7   | 6   | 5   | 4   | 3 | 2    | 1    | 0    | Address | At reset | R/W                   |
|--------|-----|-----|-----|-----|---|------|------|------|---------|----------|-----------------------|
| PCC    | MCC | FRC | CLS | CSS | 0 | PCC2 | PCC1 | PCC0 | FFFBH   | 04H      | R/W <sup>Note 1</sup> |

| R/W    | CSS | PCC2 | PCC1 | PCC0               | Selects CPU clock ( $f_{CPU}$ ) |
|--------|-----|------|------|--------------------|---------------------------------|
| 0      | 0   | 0    | 0    | 0                  | $f_{xx}$                        |
|        |     |      |      |                    | $f_{xx}/2$                      |
|        |     |      |      |                    | $f_{xx}/2^2$                    |
|        |     |      |      |                    | $f_{xx}/2^3$                    |
|        |     |      |      |                    | $f_{xx}/2^4$                    |
| 1      | 0   | 0    | 0    | 0                  | $f_{XT}/2$                      |
|        |     |      |      |                    | $f_{XT}/2$                      |
|        |     |      |      |                    | $f_{XT}/2$                      |
|        |     |      |      |                    | $f_{XT}/2$                      |
|        |     |      |      |                    | $f_{XT}/2$                      |
| Others |     |      |      | Setting prohibited |                                 |

| R | CLS | Status of CPU clock |
|---|-----|---------------------|
|   | 0   | Main system clock   |
|   | 1   | Subsystem clock     |

| R/W | FRC | Selects feedback resistor of subsystem clock |
|-----|-----|--|
|     | 0   | Uses internal feedback resistor              |
|     | 1   | Does not use internal feedback resistor      |

| R/W | MCC | Controls oscillation of main system clock <sup>Note 2</sup> |
|-----|-----|---|
|     | 0   | Enables oscillation   |
|     | 1   | Stops oscillation   |

**Notes 1.** Bit 5 is a read-only bit.

2. Use MCC to stop the oscillation of the main system clock when the CPU operates on the subsystem clock. Do not use the STOP instruction.

**Caution** Be sure to clear bit 3 to 0.

- Remarks 1.**  $f_{xx}$ : main system clock frequency
2.  $f_{XT}$ : subsystem clock oscillation frequency

★ **Figure 3-4. Format of Processor Clock Control Register ( $\mu$ PD780018, 780018Y subseries)**

|        |     |     |     |     |   |      |      |      |         |          |                       |
|--------|-----|-----|-----|-----|---|------|------|------|---------|----------|-----------------------|
| Symbol | 7   | 6   | 5   | 4   | 3 | 2    | 1    | 0    | Address | At reset | R/W                   |
| PCC    | MCC | FRC | CLS | CSS | 0 | PCC2 | PCC1 | PCC0 | FFFBH   | 04H      | R/W <sup>Note 1</sup> |

|        |     |      |      |                    |                                 |           |
|--------|-----|------|------|--------------------|---------------------------------|-----------|
| R/W    | CSS | PCC2 | PCC1 | PCC0               | Selects CPU clock ( $f_{CPU}$ ) |           |
| 0      | 0   | 0    | 0    | $f_{xx}$           |                                 | $f_x$     |
|        | 0   | 0    | 1    | $f_{xx}/2$         |                                 | $f_x/2$   |
|        | 0   | 1    | 0    | $f_{xx}/2^2$       |                                 | $f_x/2^2$ |
|        | 0   | 1    | 1    | $f_{xx}/2^3$       |                                 | $f_x/2^3$ |
|        | 1   | 0    | 0    | $f_{xx}/2^4$       |                                 | $f_x/2^4$ |
| 1      | 0   | 0    | 0    | $f_{xt}/2$         |                                 |           |
|        | 0   | 0    | 1    |                    |                                 |           |
|        | 0   | 1    | 0    |                    |                                 |           |
|        | 0   | 1    | 1    |                    |                                 |           |
|        | 1   | 0    | 0    |                    |                                 |           |
| Others |     |      |      | Setting prohibited |                                 |           |

|   |                   |                     |
|---|-------------------|---------------------|
| R | CLS               | Status of CPU clock |
| 0 | Main system clock |                     |
| 1 | Subsystem clock   |                     |

|     |   |  |
|-----|---|--|
| R/W | FRC                                     | Selects feedback resistor of subsystem clock |
| 0   | Uses internal feedback resistor         |  |
| 1   | Does not use internal feedback resistor |  |

|     |                     |   |
|-----|---------------------|---|
| R/W | MCC                 | Controls oscillation of main system clock <sup>Note 2</sup> |
| 0   | Enables oscillation |   |
| 1   | Stops oscillation   |   |

**Notes 1.** Bit 5 is a read-only bit.

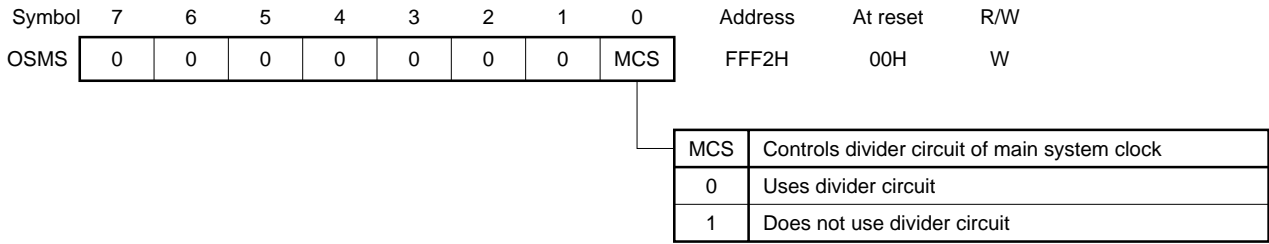
2. Use MCC to stop the oscillation of the main system clock when the CPU operates on the subsystem clock. Do not use the STOP instruction.

**Caution** Be sure to clear bit 3 to 0.

- Remarks 1.**  $f_{xx}$ : main system clock frequency ( $f_x$ )
2.  $f_x$  : main system clock oscillation frequency
  3.  $f_{xt}$ : subsystem clock oscillation frequency

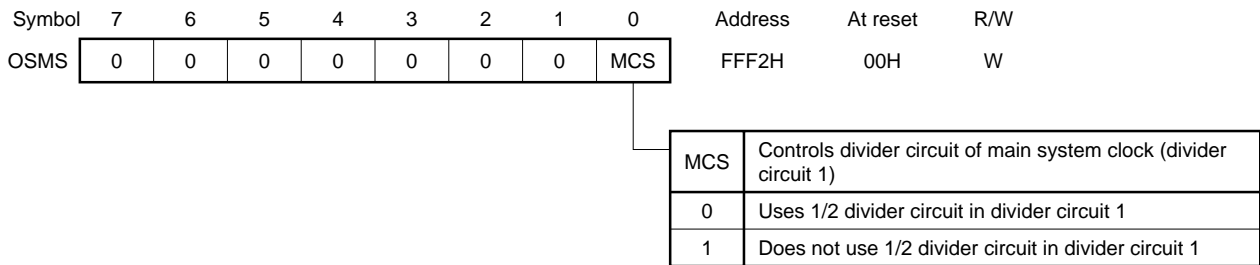
Figure 3-5. Format of Oscillation Mode Select Register

( $\mu$ PD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 78083, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY subseries,  $\mu$ PD78070A, 78070AY)



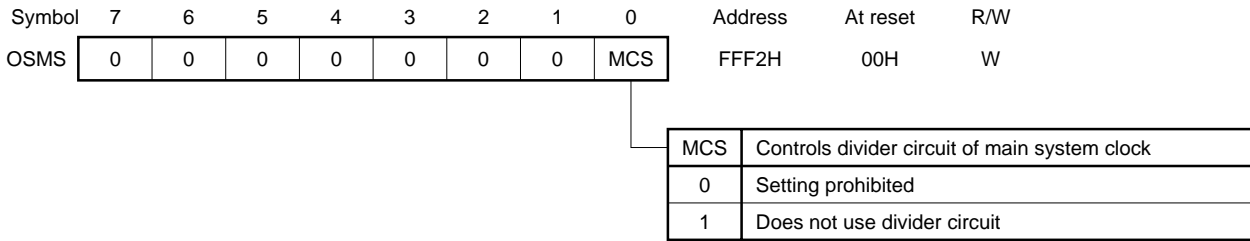
- Cautions 1.** When an instruction that writes a value to the OSMS is executed (including when the instruction is executed to write the same value), the main system clock cycle is extended up to 2/fx only during the execution of the write instruction. Consequently, a temporary error of the count clock cycle of the peripheral hardware units that operate on the main system clock, such as timers, occurs. When the oscillation mode is changed, the clock supplied to the peripheral hardware, as well as the clock supplied to the CPU, is changed. It is therefore recommended that you execute the instruction to write the OSMS only once after the reset signal has been deasserted, and before the peripheral hardware operates.
- 2.** Set 1 to MCS after V<sub>DD</sub> has risen to 2.7 V or more.

Figure 3-6. Format of Oscillation Mode Select Register ( $\mu$ PD78098, 78098B subseries)



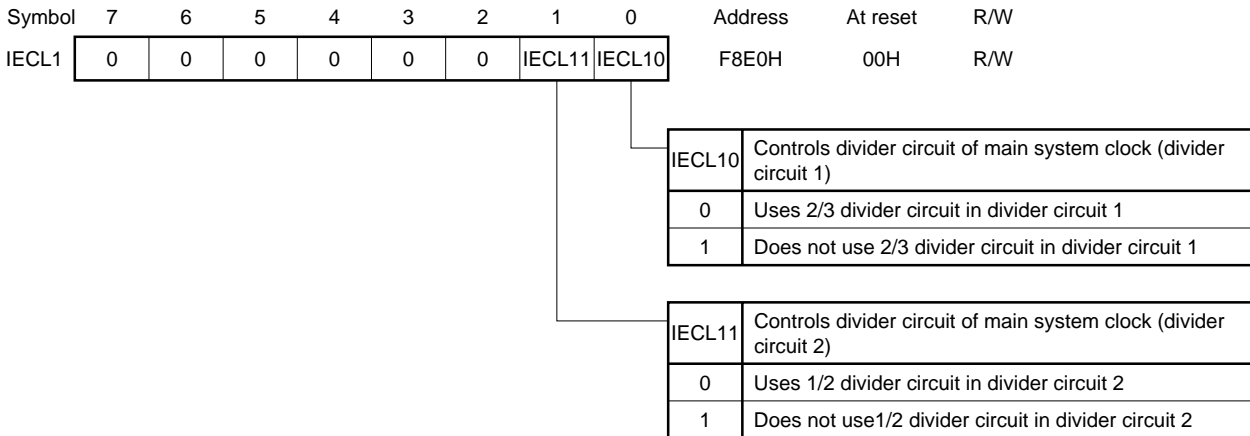
**Caution** When an instruction that writes a value to the OSMS is executed (including when the instruction is executed to write the same value), the main system clock cycle is extended up to 2/fx only during the execution of the write instruction. Consequently, a temporary error of the count clock cycle of the peripheral hardware units that operate on the main system clock, such as timers, occurs. When the oscillation mode is changed, the clock supplied to the peripheral hardware, as well as the clock supplied to the CPU, is changed. It is therefore recommended that you execute the instruction to write the OSMS only once after the reset signal has been deasserted, and before the peripheral hardware operates.

★ **Figure 3-7. Format of Oscillation Mode Select Register ( $\mu$ PD780018, 780018Y subseries)**



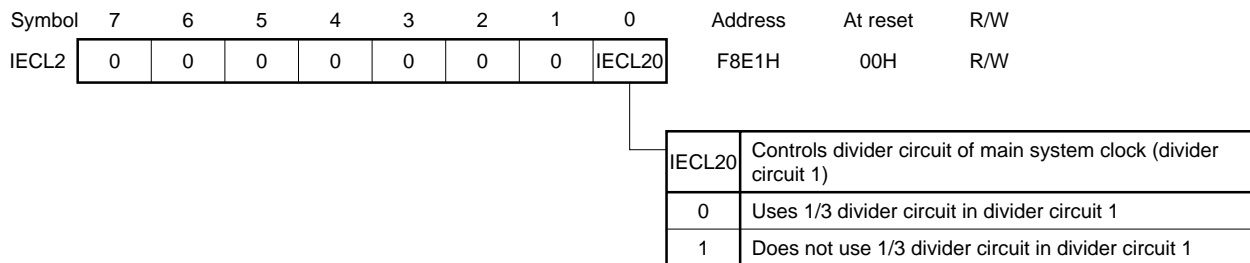
- Cautions**
1. When an instruction that writes a value to the OSMS is executed (including when the instruction is executed to write the same value), the main system clock cycle is extended up to 2/fx only during the execution of the write instruction. Consequently, a temporary error of the count clock cycle of the peripheral hardware units that operate on the main system clock, such as timers, occurs.
  2. Setting MCS to 0 is prohibited. On RESET input, however, OSMS is reset to 00H. Therefore, be sure to set MCS to 1 at the start of a program or after clearing reset.

**Figure 3-8. Format of Clock Select Register 1 ( $\mu$ PD78098, 78098B subseries)**



**Caution** Be sure to clear bits 2 through 7 to 0.

**Figure 3-9. Format of Clock Select Register 2 ( $\mu$ PD78098, 78098B subseries)**



**Caution** Be sure to clear bits 1 through 7 to 0.



The fastest instruction is executed in two CPU clocks. Therefore, the relation between the CPU clock ( $f_{CPU}$ ) and minimum instruction execution time is as shown in Tables 3-2 and 3-3.

★

**Table 3-2. Relation between CPU Clock and Minimum Instruction Execution Time (other than  $\mu$ PD78098 and 78098B subseries)**

| CPU Clock ( $f_{CPU}$ ) | Minimum Instruction Execution Time: $2/f_{CPU}$ |
|-------------------------|---|
| $f_x$                   | 0.4 $\mu$ s                                     |
| $f_x/2$                 | 0.8 $\mu$ s                                     |
| $f_x/2^2$               | 1.6 $\mu$ s                                     |
| $f_x/2^3$               | 3.2 $\mu$ s                                     |
| $f_x/2^4$               | 6.4 $\mu$ s                                     |
| $f_x/2^5$ <b>Note 1</b> | 12.8 $\mu$ s                                    |
| $f_{XT}$ <b>Note 2</b>  | 122 $\mu$ s                                     |

**Notes 1.** Except  $\mu$ PD780018 and 780018Y subseries

**2.** Except  $\mu$ PD78083 subseries

**Remark**  $f_x = 5.0$  MHz,  $f_{XT} = 32.768$  kHz

$f_x$  : Main system clock oscillation frequency

$f_{XT}$ : Subsystem clock oscillation frequency

★ Table 3-3. CPU Clock (f<sub>cpu</sub>) List (μPD78098 and 78098B Subseries)

| CSS    | PCC2 | PCC1 | PCC0 | Selects CPU clock (f <sub>cpu</sub> ) |   |  |   |  |   |  |   |  |  |
|--------|------|------|------|---------------------------------------|---|--|---|--|---|--|---|--|--|
|        |      |      |      | MCS                                   | 0   | 0  | 0   | 0  | 1   | 1  | 1   | 1  |  |
|        |      |      |      | IECL20                                | 0   | 0  | 1   | 1  | 0   | 0  | 1   | 1  |  |
|        |      |      |      | IECL10                                | 0   | 1  | 0   | 1  | 0   | 1  | 0   | 1  |  |
| 0      | 0    | 0    | 0    | f <sub>xx</sub>                       | f <sub>x</sub> /2<br>(0.67 μs)              | (2f <sub>x</sub> /3)/2<br>(1.00 μs)              | (f <sub>x</sub> /3)/2<br>(2.00 μs)              | (2f <sub>x</sub> /9)/2<br>(3.00 μs)              | f <sub>x</sub><br>(Setting prohibited)      | 2f <sub>x</sub> /3<br>(0.50 μs)                  | f <sub>x</sub> /3<br>(1.00 μs)                  | 2f <sub>x</sub> /9<br>(1.50 μs)                  |  |
|        | 0    | 0    | 1    | f <sub>xx</sub> /2                    | f <sub>x</sub> /2 <sup>2</sup><br>(1.33 μs) | (2f <sub>x</sub> /3)/2 <sup>2</sup><br>(2.00 μs) | (f <sub>x</sub> /3)/2 <sup>2</sup><br>(4.00 μs) | (2f <sub>x</sub> /9)/2 <sup>2</sup><br>(6.00 μs) | f <sub>x</sub> /2<br>(0.67 μs)              | (2f <sub>x</sub> /3)/2<br>(1.00 μs)              | (f <sub>x</sub> /3)/2<br>(2.00 μs)              | (2f <sub>x</sub> /9)/2<br>(3.00 μs)              |  |
|        | 0    | 1    | 0    | f <sub>xx</sub> /2 <sup>2</sup>       | f <sub>x</sub> /2 <sup>3</sup><br>(2.67 μs) | (2f <sub>x</sub> /3)/2 <sup>3</sup><br>(4.00 μs) | (f <sub>x</sub> /3)/2 <sup>3</sup><br>(8.00 μs) | (2f <sub>x</sub> /9)/2 <sup>3</sup><br>(12.0 μs) | f <sub>x</sub> /2 <sup>2</sup><br>(1.33 μs) | (2f <sub>x</sub> /3)/2 <sup>2</sup><br>(2.00 μs) | (f <sub>x</sub> /3)/2 <sup>2</sup><br>(4.00 μs) | (2f <sub>x</sub> /9)/2 <sup>2</sup><br>(6.00 μs) |  |
|        | 0    | 1    | 1    | f <sub>xx</sub> /2 <sup>3</sup>       | f <sub>x</sub> /2 <sup>4</sup><br>(5.33 μs) | (2f <sub>x</sub> /3)/2 <sup>4</sup><br>(8.00 μs) | (f <sub>x</sub> /3)/2 <sup>4</sup><br>(16.0 μs) | (2f <sub>x</sub> /9)/2 <sup>4</sup><br>(24.0 μs) | f <sub>x</sub> /2 <sup>3</sup><br>(2.67 μs) | (2f <sub>x</sub> /3)/2 <sup>3</sup><br>(4.00 μs) | (f <sub>x</sub> /3)/2 <sup>3</sup><br>(8.00 μs) | (2f <sub>x</sub> /9)/2 <sup>3</sup><br>(12.0 μs) |  |
|        | 1    | 0    | 0    | f <sub>xx</sub> /2 <sup>4</sup>       | f <sub>x</sub> /2 <sup>5</sup><br>(10.7 μs) | (2f <sub>x</sub> /3)/2 <sup>5</sup><br>(16.0 μs) | (f <sub>x</sub> /3)/2 <sup>5</sup><br>(32.0 μs) | (2f <sub>x</sub> /9)/2 <sup>5</sup><br>(48.0 μs) | f <sub>x</sub> /2 <sup>4</sup><br>(5.33 μs) | (2f <sub>x</sub> /3)/2 <sup>4</sup><br>(8.00 μs) | (f <sub>x</sub> /3)/2 <sup>4</sup><br>(16.0 μs) | (2f <sub>x</sub> /9)/2 <sup>4</sup><br>(24.0 μs) |  |
| 1      | 0    | 0    | 0    | f <sub>xT</sub> /2(122 μs)            |   |  |   |  |   |  |   |  |  |
|        | 0    | 0    | 1    |                                       |   |  |   |  |   |  |   |  |  |
|        | 0    | 1    | 0    |                                       |   |  |   |  |   |  |   |  |  |
|        | 0    | 1    | 1    |                                       |   |  |   |  |   |  |   |  |  |
|        | 1    | 0    | 0    |                                       |   |  |   |  |   |  |   |  |  |
| Others |      |      |      | Setting prohibited                    |   |  |   |  |   |  |   |  |  |

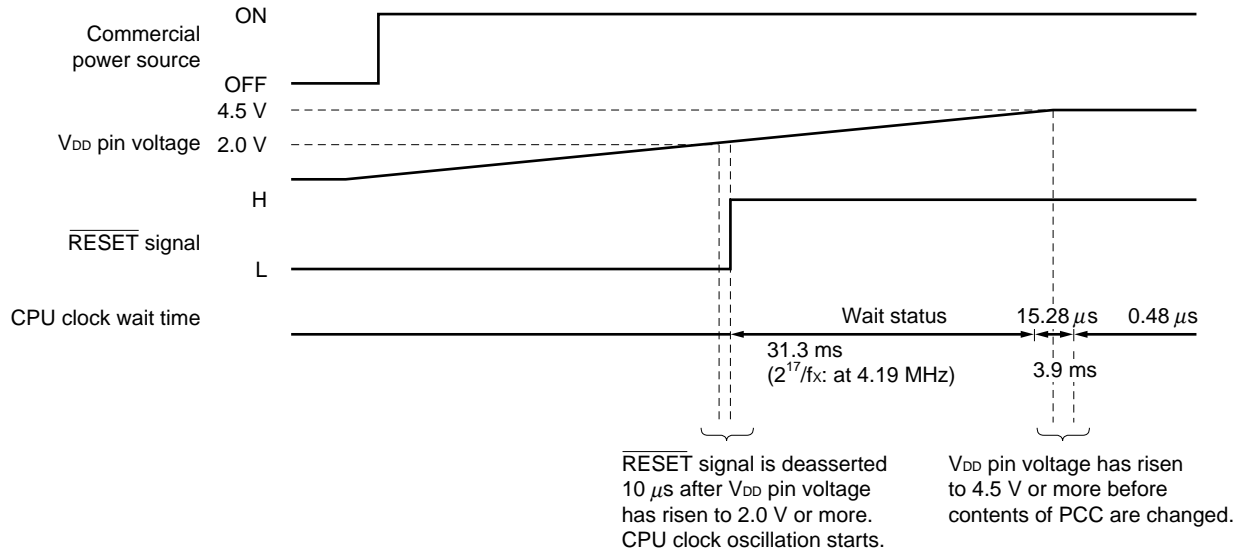
- Remarks 1.** f<sub>x</sub> : Main system clock oscillation frequency  
**2.** f<sub>xx</sub> : Main system clock frequency  
**3.** f<sub>xT</sub> : Subsystem clock oscillation frequency  
**4.** ( ) : Minimum instruction execution time with f<sub>x</sub> = 6.0 MHz or f<sub>xT</sub> = 32.768 kHz: 2/f<sub>cpu</sub>

### 3.1 Changing PCC Immediately after $\overline{\text{RESET}}$

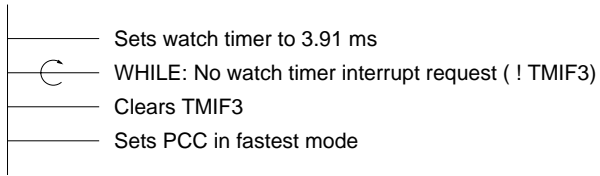
When the  $\overline{\text{RESET}}$  signal is asserted, the slowest mode (processor clock control register: PCC = 04H, oscillation mode select register: OSMS = 00H) of the main system clock is selected for the CPU clock. To set the highest speed of the CPU clock, therefore, the contents of the PCC must be rewritten (PCC = 00H, OSMS = 01H). To use the fastest mode, however, the voltage on the V<sub>DD</sub> pin has to have risen to a sufficient level and be stable.

In the following example, the CPU waits until the V<sub>DD</sub> pin voltage has risen to the sufficient level by using the watch timer (the interval time is set to 3.91 ms). After that, the CPU operates on the fastest clock.

**Figure 3-10. Example of Selecting CPU Clock after  $\overline{\text{RESET}}$  (with  $\mu\text{PD78054}$  subseries)**



(1) SPD chart



(2) Program list

```

;*****
;*      Sets wait time
;*****
    TCL2=#00010000B
    TMC2=#00110110B      ; Sets watch timer to 3.91 ms
    while_bit(!TMIF3)    ; 3.91 ms?
    endw
    CLR1   WTIF
    OSMS=#00000001B      ; Does not use divider circuit
    PCC=#00000000B      ; Sets CPU clock in fastest mode
    
```

### 3.2 Selecting Power ON/OFF

The 78K/0 series can operate in an ultra low current consumption mode by using the processor clock control register (PCC) and selecting the subsystem clock. By providing a backup power supply such as a Ni-Cd battery or super capacitor to the system, therefore, the system can continue operating even if a power failure occurs.

In this example, a power failure is detected by using INTP1 (both the rising and falling edges are selected as the edge to be detected), and the contents of the PCC are changed depending on the port level at that time. Figure 3-11 shows a circuit example, and Figure 3-12 shows the system clock changing timing.

**Figure 3-11. Example of System Clock Changing Circuit**

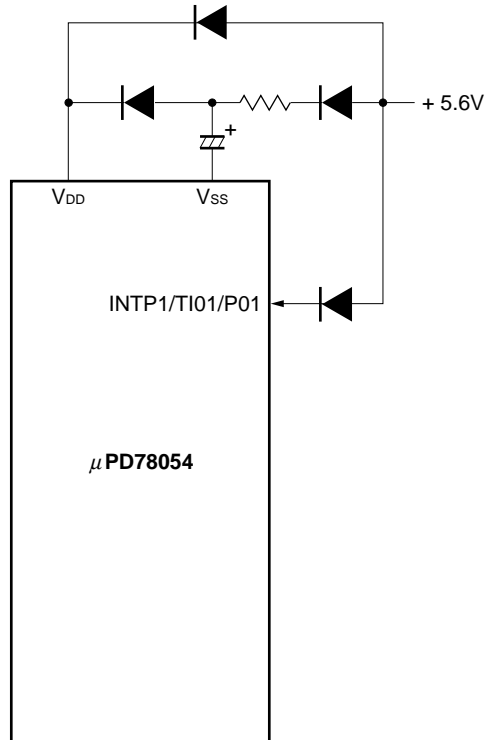
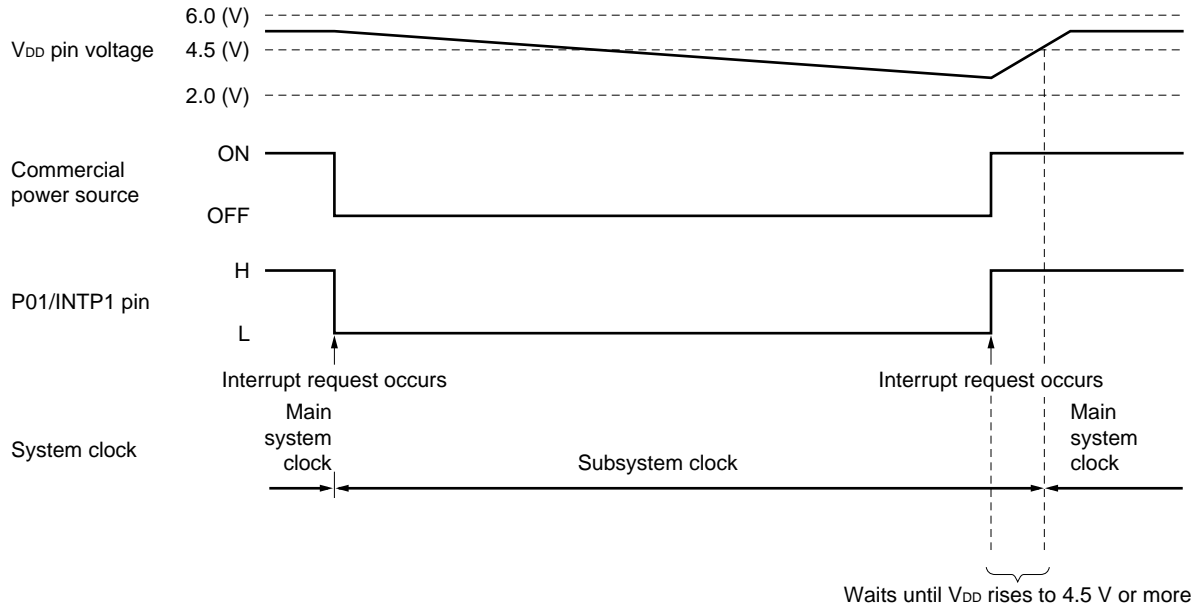
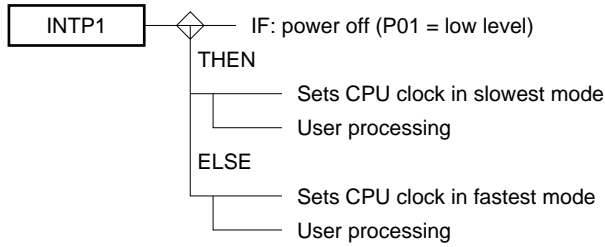


Figure 3-12. Example of Changing System Clock on Power Failure ( $\mu$ PD78054 subseries)



(1) SPD chart



(2) Program list

```

VEP0   CSEG   AT 08H
        DW     INTTP1           ; Sets vector address of INTTP1

        MOV    INTM0,#00110000B ; Both edge detection mode
        CLR1   PMK1
        EI

;*****
;*      Sets low-/high-speed mode
;*****
INTTP1:
        if_bit(!P0.1)
;      Setting of internal hardware (low speed)
;      User processing

        PCC=#10010000B         ; Sets low-speed mode

        else
;      Sets internal hardware (high speed)
;      User processing

        PCC=#00000000B         ; Sets high-speed mode

        endif
        RETI
  
```

[MEMO]



## CHAPTER 4 APPLICATIONS OF WATCHDOG TIMER

The watchdog timer of the 78K/0 series has two modes: watchdog timer mode in which a hang-up of the microcontroller is detected, and interval timer mode.

The watchdog timer is set by using timer clock select register 2 (TCL2) and watchdog timer mode register (WDTM).

Figure 4-1. Format of Timer Clock Select Register 2

( $\mu$ PD78054 78054Y, 78064, 78064Y, 78078, 78078Y, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY subseries,  $\mu$ PD78070A, 78070AY)

|        |       |       |       |       |   |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|---|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3 | 2     | 1     | 0     | Address | At reset | R/W |
| TCL2   | TCL27 | TCL26 | TCL25 | TCL24 | 0 | TCL22 | TCL21 | TCL20 | FF42H   | 00H      | R/W |

| TCL22 | TCL21 | TCL20 | Selects count clock of watchdog timer |                        |                        |
|-------|-------|-------|---------------------------------------|------------------------|------------------------|
|       |       |       |                                       | MCS = 1                | MCS = 0                |
| 0     | 0     | 0     | $f_{xx}/2^3$                          | $f_x/2^3$ (625 kHz)    | $f_x/2^4$ (313 kHz)    |
| 0     | 0     | 1     | $f_{xx}/2^4$                          | $f_x/2^4$ (313 kHz)    | $f_x/2^5$ (156 kHz)    |
| 0     | 1     | 0     | $f_{xx}/2^5$                          | $f_x/2^5$ (156 kHz)    | $f_x/2^6$ (78.1 kHz)   |
| 0     | 1     | 1     | $f_{xx}/2^6$                          | $f_x/2^6$ (78.1 kHz)   | $f_x/2^7$ (39.1 kHz)   |
| 1     | 0     | 0     | $f_{xx}/2^7$                          | $f_x/2^7$ (39.1 kHz)   | $f_x/2^8$ (19.5 kHz)   |
| 1     | 0     | 1     | $f_{xx}/2^8$                          | $f_x/2^8$ (19.5 kHz)   | $f_x/2^9$ (9.8 kHz)    |
| 1     | 1     | 0     | $f_{xx}/2^9$                          | $f_x/2^9$ (9.8 kHz)    | $f_x/2^{10}$ (4.9 kHz) |
| 1     | 1     | 1     | $f_{xx}/2^{11}$                       | $f_x/2^{11}$ (2.4 kHz) | $f_x/2^{12}$ (1.2 kHz) |

| TCL24 | Selects count clock of watch timer |                      |                      |
|-------|------------------------------------|----------------------|----------------------|
|       |                                    | MCS = 1              | MCS = 0              |
| 0     | $f_{xx}/2^7$                       | $f_x/2^7$ (39.1 kHz) | $f_x/2^8$ (19.5 kHz) |
| 1     | $f_{XT}$ (32.768 kHz)              |                      |                      |

| TCL27 | TCL26 | TCL25 | Selects frequency of buzzer output |                        |                        |
|-------|-------|-------|------------------------------------|------------------------|------------------------|
|       |       |       |                                    | MCS = 1                | MCS = 0                |
| 0     | ×     | ×     | Disables buzzer output             |                        |                        |
| 1     | 0     | 0     | $f_{xx}/2^9$                       | $f_x/2^9$ (9.8 kHz)    | $f_x/2^{10}$ (4.9 kHz) |
| 1     | 0     | 1     | $f_{xx}/2^{10}$                    | $f_x/2^{10}$ (4.9 kHz) | $f_x/2^{11}$ (2.4 kHz) |
| 1     | 1     | 0     | $f_{xx}/2^{11}$                    | $f_x/2^{11}$ (2.4 kHz) | $f_x/2^{12}$ (1.2 kHz) |
| 1     | 1     | 1     | Setting prohibited                 |                        |                        |

**Caution** To change the data of TCL2 except when writing the same data, once stop the timer operation.

- Remarks**
1.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  2.  $f_x$  : main system clock oscillation frequency
  3.  $f_{XT}$  : subsystem clock oscillation frequency
  4. × : don't care
  5. MCS: bit 0 of oscillation mode select register (OSMS)
  6. ( ) :  $f_x = 5.0$  MHz or  $f_{XT} = 32.768$  kHz

Figure 4-2. Format of Timer Clock Select Register 2 ( $\mu$ PD78083 subseries)

|        |       |       |       |   |   |       |       |       |         |          |     |
|--------|-------|-------|-------|---|---|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4 | 3 | 2     | 1     | 0     | Address | At reset | R/W |
| TCL2   | TCL27 | TCL26 | TCL25 | 0 | 0 | TCL22 | TCL21 | TCL20 | FF42H   | 00H      | R/W |

| TCL22 | TCL21 | TCL20 | Selects count clock of watchdog timer |                        |                        |
|-------|-------|-------|---------------------------------------|------------------------|------------------------|
|       |       |       |                                       | MCS = 1                | MCS = 0                |
| 0     | 0     | 0     | $f_{xx}/2^3$                          | $f_x/2^3$ (625 kHz)    | $f_x/2^4$ (313 kHz)    |
| 0     | 0     | 1     | $f_{xx}/2^4$                          | $f_x/2^4$ (313 kHz)    | $f_x/2^5$ (156 kHz)    |
| 0     | 1     | 0     | $f_{xx}/2^5$                          | $f_x/2^5$ (156 kHz)    | $f_x/2^6$ (78.1 kHz)   |
| 0     | 1     | 1     | $f_{xx}/2^6$                          | $f_x/2^6$ (78.1 kHz)   | $f_x/2^7$ (39.1 kHz)   |
| 1     | 0     | 0     | $f_{xx}/2^7$                          | $f_x/2^7$ (39.1 kHz)   | $f_x/2^8$ (19.5 kHz)   |
| 1     | 0     | 1     | $f_{xx}/2^8$                          | $f_x/2^8$ (19.5 kHz)   | $f_x/2^9$ (9.8 kHz)    |
| 1     | 1     | 0     | $f_{xx}/2^9$                          | $f_x/2^9$ (9.8 kHz)    | $f_x/2^{10}$ (4.9 kHz) |
| 1     | 1     | 1     | $f_{xx}/2^{11}$                       | $f_x/2^{11}$ (2.4 kHz) | $f_x/2^{12}$ (1.2 kHz) |

| TCL27 | TCL26 | TCL25 | Selects frequency of buzzer output |                        |                        |
|-------|-------|-------|------------------------------------|------------------------|------------------------|
|       |       |       |                                    | MCS = 1                | MCS = 0                |
| 0     | ×     | ×     | Disables buzzer output             |                        |                        |
| 1     | 0     | 0     | $f_{xx}/2^9$                       | $f_x/2^9$ (9.8 kHz)    | $f_x/2^{10}$ (4.9 kHz) |
| 1     | 0     | 1     | $f_{xx}/2^{10}$                    | $f_x/2^{10}$ (4.9 kHz) | $f_x/2^{11}$ (2.4 kHz) |
| 1     | 1     | 0     | $f_{xx}/2^{11}$                    | $f_x/2^{11}$ (2.4 kHz) | $f_x/2^{12}$ (1.2 kHz) |
| 1     | 1     | 1     | Setting prohibited                 |                        |                        |

- Cautions 1.** To change the data of TCL2 except when writing the same data, once stop the timer operation.  
**2.** Be sure to clear bits 3 and 4 to 0.

- Remarks 1.**  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )  
**2.**  $f_x$  : main system clock oscillation frequency  
**3.** × : don't care  
**4.** MCS: bit 0 of oscillation mode select register (OSMS)  
**5.** ( ) :  $f_x = 5.0$  MHz

Figure 4-3. Format of Timer Clock Select Register 2 ( $\mu$ PD78098, 78098B subseries)

|        |       |       |       |       |   |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|---|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3 | 2     | 1     | 0     | Address | At reset | R/W |
| TCL2   | TCL27 | TCL26 | TCL25 | TCL24 | 0 | TCL22 | TCL21 | TCL20 | FF42H   | 00H      | R/W |

| TCL22 | TCL21 | TCL20 | Selects count clock of watchdog timer |
|-------|-------|-------|---------------------------------------|
| 0     | 0     | 0     | $f_{xx}/2^3$ (500 kHz)                |
| 0     | 0     | 1     | $f_{xx}/2^4$ (250 kHz)                |
| 0     | 1     | 0     | $f_{xx}/2^5$ (125 kHz)                |
| 0     | 1     | 1     | $f_{xx}/2^6$ (62.5 kHz)               |
| 1     | 0     | 0     | $f_{xx}/2^7$ (31.3 kHz)               |
| 1     | 0     | 1     | $f_{xx}/2^8$ (15.6 kHz)               |
| 1     | 1     | 0     | $f_{xx}/2^9$ (7.8 kHz)                |
| 1     | 1     | 1     | $f_{xx}/2^{11}$ (2.0 kHz)             |

| TCL24 | Selects count clock of watch timer |
|-------|------------------------------------|
| 0     | $f_{xx}/2^7$ (31.3 kHz)            |
| 1     | $f_{XT}$ (32.768 kHz)              |

| TCL27 | TCL26 | TCL25 | Selects frequency of buzzer output |
|-------|-------|-------|------------------------------------|
| 0     | ×     | ×     | Disables buzzer output             |
| 1     | 0     | 0     | $f_{xx}/2^9$ (7.8 kHz)             |
| 1     | 0     | 1     | $f_{xx}/2^{10}$ (3.9 kHz)          |
| 1     | 1     | 0     | $f_{xx}/2^{11}$ (1.95 kHz)         |
| 1     | 1     | 1     | Setting prohibited                 |

**Caution** To change the data of TCL2 except when writing the same data, once stop the timer operation.

- Remarks**
1.  $f_{xx}$ : main system clock frequency
  2.  $f_{XT}$ : subsystem clock oscillation frequency
  3. × : don't care
  4. ( ):  $f_{xx} = 4.0$  MHz or  $f_{XT} = 32.768$  kHz

★ **Figure 4-4. Format of Timer Clock Select Register 2 ( $\mu$ PD780018, 780018Y subseries)**

|        |       |       |       |       |   |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|---|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3 | 2     | 1     | 0     | Address | At reset | R/W |
| TCL2   | TCL27 | TCL26 | TCL25 | TCL24 | 0 | TCL22 | TCL21 | TCL20 | FF42H   | 00H      | R/W |

|       |       |       |                                       |                        |
|-------|-------|-------|---------------------------------------|------------------------|
| TCL22 | TCL21 | TCL20 | Selects count clock of watchdog timer |                        |
| 0     | 0     | 0     | $f_{xx}/2^3$                          | $f_x/2^3$ (625 kHz)    |
| 0     | 0     | 1     | $f_{xx}/2^4$                          | $f_x/2^4$ (313 kHz)    |
| 0     | 1     | 0     | $f_{xx}/2^5$                          | $f_x/2^5$ (156 kHz)    |
| 0     | 1     | 1     | $f_{xx}/2^6$                          | $f_x/2^6$ (78.1 kHz)   |
| 1     | 0     | 0     | $f_{xx}/2^7$                          | $f_x/2^7$ (39.1 kHz)   |
| 1     | 0     | 1     | $f_{xx}/2^8$                          | $f_x/2^8$ (19.5 kHz)   |
| 1     | 1     | 0     | $f_{xx}/2^9$                          | $f_x/2^9$ (9.8 kHz)    |
| 1     | 1     | 1     | $f_{xx}/2^{11}$                       | $f_x/2^{11}$ (2.4 kHz) |

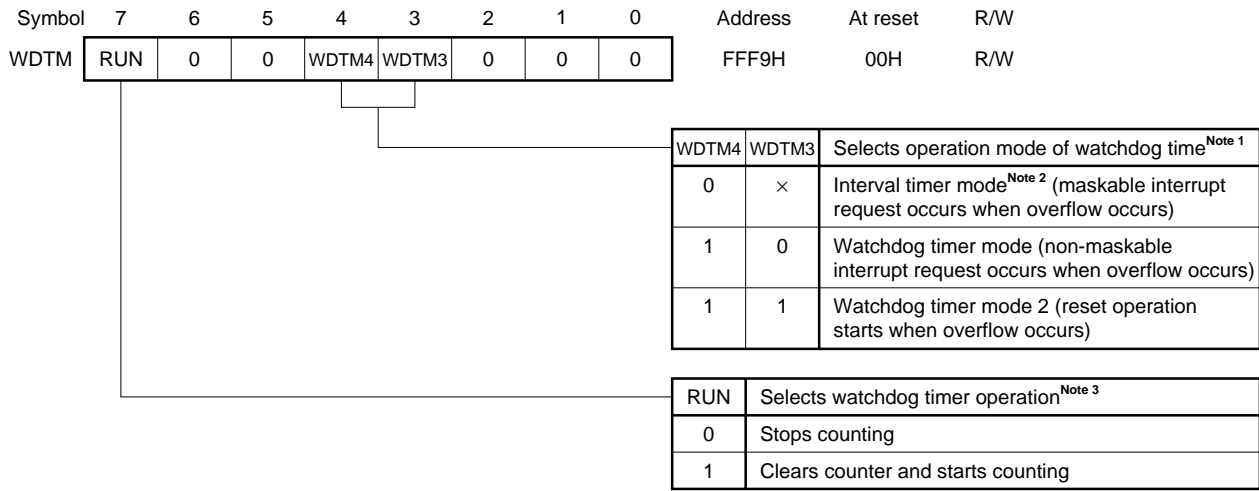
|       |                                    |                      |
|-------|------------------------------------|----------------------|
| TCL24 | Selects count clock of watch timer |                      |
| 0     | $f_{xx}/2^7$                       | $f_x/2^7$ (39.1 kHz) |
| 1     | $f_{XT}$ (32.768 kHz)              |                      |

|       |       |       |                                    |                        |
|-------|-------|-------|------------------------------------|------------------------|
| TCL27 | TCL26 | TCL25 | Selects frequency of buzzer output |                        |
| 0     | ×     | ×     | Disables buzzer output             |                        |
| 1     | 0     | 0     | $f_{xx}/2^9$                       | $f_x/2^9$ (9.8 kHz)    |
| 1     | 0     | 1     | $f_{xx}/2^{10}$                    | $f_x/2^{10}$ (4.9 kHz) |
| 1     | 1     | 0     | $f_{xx}/2^{11}$                    | $f_x/2^{11}$ (2.4 kHz) |
| 1     | 1     | 1     | Setting prohibited                 |                        |

**Caution** To change the data of TCL2 except when writing the same data, once stop the timer operation.

- Remarks**
1.  $f_{xx}$  : main system clock frequency (fx)
  2.  $f_x$  : main system clock oscillation frequency
  3.  $f_{XT}$  : subsystem clock oscillation frequency
  4. × : don't care
  5. ( ) :  $f_x = 5.0$  MHz or  $f_{XT} = 32.768$  kHz

★ **Figure 4-5. Format of Watchdog Timer Mode Register**



- Notes**
1. Once WDTM3 and WDTM4 have been set to 1, they cannot be cleared to 0 by software.
  2. When RUN is set to 1, the WDTM starts interval timer operation.
  3. Once RUN has been set to 1, it cannot be cleared to 0 by software. Therefore, when counting has been started, it cannot be stopped by any means other than the  $\overline{\text{RESET}}$  signal.

- Caution**
1. When RUN is set to 1 and the watchdog timer is cleared, the actual overflow time is up to 0.5% shorter than the time set by the timer clock select register 2.
  2. When using the watchdog timer modes 1 and 2, confirm that the interrupt request flag (TMIF4) is 0 and then set WDTM4 to 1. If WDTM4 is set to 1 while TMIF4 is 1, the non-maskable interrupt occurs regardless of the contents of WDTM3.

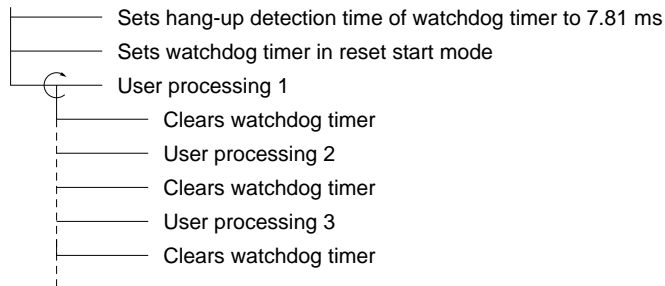
## 4.1 Setting Watchdog Timer Mode

Reset processing or non-maskable interrupt processing is performed after the watchdog timer has detected a hang-up. You can select which processing is to be performed by the watchdog timer mode register (WDTM). When the watchdog timer mode is used, the timer must be cleared at intervals shorter than the set hang-up detection time. If the timer is not cleared, an overflow occurs, and reset or interrupt processing is executed.

The hang-up detection time of the watchdog timer is set by the timer clock select register 2 (TCL2).

In the following example, the hang-up detection time is set to 7.81 ms and the reset processing is performed when an overflow occurs.

### (1) SPD chart



## (2) Program list

```
;*****  
;*   Sets watchdog timer  
;*****  
  
    OSMS=#00000001B           ; Does not use divider circuit  
    TCL2=#00000100B           ; Sets watchdog timer to 7.81 ms  
    WDTM=#10011000B           ; Sets reset start mode  
;  
    User processing 1  
    ;  
    SET1    RUN                ; Clears timer  
;  
    User processing 2  
    ;  
    SET1    RUN                ; Clears timer  
;  
    User processing 3  
    ;  
    SET1    RUN                ; Clears timer  
    ;
```

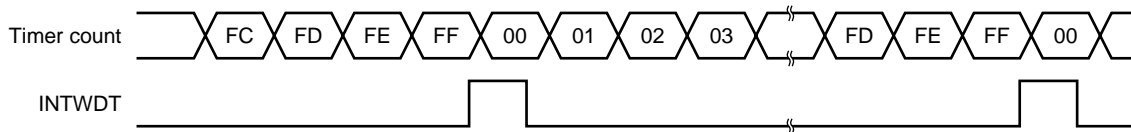


## 4.2 Setting Interval Timer Mode

When the interval timer mode is used, the interval time is set by the timer clock select register 2 (TCL2) (interval time = 0.488 ms to 125 ms, at  $f_x = 4.19$  MHz). In this mode, an interrupt request flag (TMIF4) is set when an overflow occurs in the timer.

In the following example, three types of times, 0.977 ms, 7.82 ms, and 125 ms, are set.

**Figure 4-6. Count Timing of Watchdog Timer**



### (1) Program list

```
<1> To set 0.977 ms
    TCL2=#00000001B    ; Sets 0.977 ms
    WDTM=#10001000B   ; Selects interval timer mode

<2> To set 7.82 ms
    TCL2=#00000100B   ; Sets 7.82 ms
    WDTM=#10001000B   ; Selects interval timer mode

<3> To set 125 ms
    TCL2=#00000111B   ; Sets 125 ms
    WDTM=#10001000B   ; Selects interval timer mode
```

**Remark** The above interval time is the value when OSMS = 01H.

[MEMO]

## CHAPTER 5 APPLICATIONS OF 16-BIT TIMER/EVENT COUNTER

The 16-bit timer/event counter of the 78K/0 series has the following six functions:

- Interval timer
- PWM output
- Pulse width measurement
- External event counter
- Square wave output
- One-shot pulse output

The 16-bit timer/event counter is set by the following registers:

- Timer clock select register 0 (TCL0)
- 16-bit timer mode control register (TMC0)
- Capture/compare control register 0 (CRC0)
- 16-bit timer output control register (TOC0)
- Port mode register 3 (PM3)
- External interrupt mode register (INTM0)
- Sampling clock select register (SCS)

Figure 5-1. Format of Timer Clock Select Register 0

( $\mu$ PD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY subseries,  $\mu$ PD78070A, 78070AY)

|        |      |       |       |       |       |       |       |       |         |          |     |
|--------|------|-------|-------|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7    | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TCL0   | CLOE | TCL06 | TCL05 | TCL04 | TCL03 | TCL02 | TCL01 | TCL00 | FF40H   | 00H      | R/W |

| TCL03  | TCL02 | TCL01 | TCL00 | Selects clock of PCL output |                      |                      |
|--------|-------|-------|-------|-----------------------------|----------------------|----------------------|
|        |       |       |       | MCS = 1                     |                      | MCS = 0              |
| 0      | 0     | 0     | 0     | $f_{XT}$ (32.768 kHz)       |                      |                      |
| 0      | 1     | 0     | 1     | $f_{xx}$                    | $f_x$ (5.0 MHz)      | $f_x/2$ (2.5 MHz)    |
| 0      | 1     | 1     | 0     | $f_{xx}/2$                  | $f_x/2$ (2.5 MHz)    | $f_x/2^2$ (1.25 MHz) |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$                | $f_x/2^2$ (1.25 MHz) | $f_x/2^3$ (625 kHz)  |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$                | $f_x/2^3$ (625 kHz)  | $f_x/2^4$ (313 kHz)  |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$                | $f_x/2^4$ (313 kHz)  | $f_x/2^5$ (156 kHz)  |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$                | $f_x/2^5$ (156 kHz)  | $f_x/2^6$ (78.1 kHz) |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$                | $f_x/2^6$ (78.1 kHz) | $f_x/2^7$ (39.1 kHz) |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$                | $f_x/2^7$ (39.1 kHz) | $f_x/2^8$ (19.5 kHz) |
| Others |       |       |       | Setting prohibited          |                      |                      |

| TCL06  | TCL05 | TCL04 | Selects count clock of 16-bit timer register |                      |                      |
|--------|-------|-------|--|----------------------|----------------------|
|        |       |       | MCS = 1                                      |                      | MCS = 0              |
| 0      | 0     | 0     | TI00 (valid edge can be specified)           |                      |                      |
| 0      | 0     | 1     | $2f_{xx}$                                    | Setting prohibited   | $f_x$ (5.0 MHz)      |
| 0      | 1     | 0     | $f_{xx}$                                     | $f_x$ (5.0 MHz)      | $f_x/2$ (2.5 MHz)    |
| 0      | 1     | 1     | $f_{xx}/2$                                   | $f_x/2$ (2.5 MHz)    | $f_x/2^2$ (1.25 MHz) |
| 1      | 0     | 0     | $f_{xx}/2^2$                                 | $f_x/2^2$ (1.25 MHz) | $f_x/2^3$ (625 kHz)  |
| 1      | 1     | 1     | Watch timer output (INTTM3)                  |                      |                      |
| Others |       |       | Setting prohibited                           |                      |                      |

| CLOE | Controls PCL output |
|------|---------------------|
| 0    | Disables output     |
| 1    | Enables output      |

- Cautions 1.** The valid edge of the TI00/INTP0 pin is specified by the external interrupt mode register 0 (INTM0). The frequency of the sampling clock is selected by the sampling clock select register (SCS).
- To enable PCL output, set TCL00 through TCL03, and then set CLOE to 1 by using a 1-bit memory manipulation instruction.
  - Read the count value from TM0, not from the capture/compare register 01(CR01), when TI00 is specified as the count clock of TM0.
  - Before writing new data to TCL0, stop the timer operation once.

- Remarks**
1.  $f_{XX}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  2.  $f_x$  : main system clock oscillation frequency
  3.  $f_{XT}$  : subsystem clock oscillation frequency
  4. TI00 : input pin of 16-bit timer/event counter
  5. TM0 : 16-bit timer register
  6. MCS: bit 0 of oscillation mode select register (OSMS)
  7. ( ) : at  $f_x = 5.0$  MHz or  $f_{XT} = 32.768$  kHz

Figure 5-2. Format of Timer Clock Select Register 0 ( $\mu$ PD78098, 78098B subseries)

|        |      |       |       |       |       |       |       |       |         |          |     |
|--------|------|-------|-------|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7    | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TCL0   | CLOE | TCL06 | TCL05 | TCL04 | TCL03 | TCL02 | TCL01 | TCL00 | FF40H   | 00H      | R/W |

| TCL03  | TCL02 | TCL01 | TCL00 | Selects clock of PCL output |
|--------|-------|-------|-------|-----------------------------|
| 0      | 0     | 0     | 0     | $f_{XT}$ (32.768 kHz)       |
| 0      | 1     | 0     | 1     | $f_{XX}$ (4.0 MHz)          |
| 0      | 1     | 1     | 0     | $f_{XX}/2$ (2.0 MHz)        |
| 0      | 1     | 1     | 1     | $f_{XX}/2^2$ (1.0 MHz)      |
| 1      | 0     | 0     | 0     | $f_{XX}/2^3$ (500 kHz)      |
| 1      | 0     | 0     | 1     | $f_{XX}/2^4$ (250 kHz)      |
| 1      | 0     | 1     | 0     | $f_{XX}/2^5$ (125 kHz)      |
| 1      | 0     | 1     | 1     | $f_{XX}/2^6$ (62.5 kHz)     |
| 1      | 1     | 0     | 0     | $f_{XX}/2^7$ (31.3 kHz)     |
| Others |       |       |       | Setting prohibited          |

| TCL06  | TCL05 | TCL04 | Selects count clock of 16-bit timer register |
|--------|-------|-------|--|
| 0      | 0     | 0     | TI00 (valid edge can be specified)           |
| 0      | 0     | 1     | $2f_{XX}$ <b>Note</b>                        |
| 0      | 1     | 0     | $f_{XX}$ (4.0 MHz)                           |
| 0      | 1     | 1     | $f_{XX}/2$ (2.0 MHz)                         |
| 1      | 0     | 0     | $f_{XX}/2^2$ (1.0 MHz)                       |
| 1      | 1     | 1     | Watch timer output (INTTM3)                  |
| Others |       |       | Setting prohibited                           |

| CLOE | Controls PCL output |
|------|---------------------|
| 0    | Disables output     |
| 1    | Enables output      |

**Note** At  $f_{XX} > 2.5$  MHz, setting prohibited.

**Cautions 1.** The valid edge of the TI00/INTP0 pin is specified by the external interrupt mode register 0 (INTM0). The frequency of the sampling clock is selected by the sampling clock select register (SCS).

2. To enable PCL output, set TCL00 through TCL03, and then set CLOE to 1 by using a 1-bit memory manipulation instruction.
3. Read the count value from TM0, not from the capture/compare register 01(CR01), when TI00 is specified as the count clock of TM0.
4. Before writing new data to TCL0, stop the timer operation once.

- Remarks 1.**
1.  $f_{XX}$  : main system clock frequency
  2.  $f_{XT}$  : subsystem clock oscillation frequency
  3. TI00: input pin of 16-bit timer/event counter
  4. TM0: 16-bit timer register
  5. ( ) : at  $f_{XX} = 4.0$  MHz or  $f_{XT} = 32.768$  kHz


 Figure 5-3. Format of Timer Clock Select Register 0 ( $\mu$ PD780018, 780018Y subseries)

|        |      |       |       |       |       |       |       |       |         |          |     |
|--------|------|-------|-------|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7    | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TCL0   | CLOE | TCL06 | TCL05 | TCL04 | TCL03 | TCL02 | TCL01 | TCL00 | FF40H   | 00H      | R/W |

| TCL03  | TCL02 | TCL01 | TCL00              | Selects clock of PCL output |                      |
|--------|-------|-------|--------------------|-----------------------------|----------------------|
| 0      | 0     | 0     | 0                  | $f_{XT}$ (32.768 kHz)       |                      |
| 0      | 1     | 0     | 1                  | $f_{XX}$                    | $f_x$ (5.0 MHz)      |
| 0      | 1     | 1     | 0                  | $f_{XX}/2$                  | $f_x/2$ (2.5 MHz)    |
| 0      | 1     | 1     | 1                  | $f_{XX}/2^2$                | $f_x/2^2$ (1.25 MHz) |
| 1      | 0     | 0     | 0                  | $f_{XX}/2^3$                | $f_x/2^3$ (625 kHz)  |
| 1      | 0     | 0     | 1                  | $f_{XX}/2^4$                | $f_x/2^4$ (313 kHz)  |
| 1      | 0     | 1     | 0                  | $f_{XX}/2^5$                | $f_x/2^5$ (156 kHz)  |
| 1      | 0     | 1     | 1                  | $f_{XX}/2^6$                | $f_x/2^6$ (78.1 kHz) |
| 1      | 1     | 0     | 0                  | $f_{XX}/2^7$                | $f_x/2^7$ (39.1 kHz) |
| Others |       |       | Setting prohibited |                             |                      |

| TCL06  | TCL05 | TCL04              | Selects count clock of 16-bit timer register |                      |
|--------|-------|--------------------|--|----------------------|
| 0      | 0     | 0                  | TI00 (valid edge can be specified)           |                      |
| 0      | 1     | 0                  | $f_{XX}$                                     | $f_x$ (5.0 MHz)      |
| 0      | 1     | 1                  | $f_{XX}/2$                                   | $f_x/2$ (2.5 MHz)    |
| 1      | 0     | 0                  | $f_{XX}/2^2$                                 | $f_x/2^2$ (1.25 MHz) |
| 1      | 1     | 1                  | Watch timer output (INTTM3)                  |                      |
| Others |       | Setting prohibited |  |                      |

| CLOE | Controls PCL output |
|------|---------------------|
| 0    | Disables output     |
| 1    | Enables output      |

- Cautions**
- The valid edge of the TI00/INTP0 pin is specified by the external interrupt mode register 0 (INTM0). The frequency of the sampling clock is selected by the sampling clock select register (SCS).
  - To enable PCL output, set TCL00 through TCL03, and then set CLOE to 1 by using a 1-bit memory manipulation instruction.
  - Read the count value from TM0, not from the capture/compare register 01(CR01), when TI00 is specified as the count clock of TM0.
  - Before writing new data to TCL0, stop the timer operation once.

- Remarks**
- $f_{XX}$  : main system clock frequency ( $f_x$ )
  - $f_x$  : main system clock oscillation frequency
  - $f_{XT}$  : subsystem clock oscillation frequency
  - TI00: input pin of 16-bit timer/event counter
  - TM0: 16-bit timer register
  - ( ) : at  $f_x = 5.0$  MHz or  $f_{XT} = 32.768$  kHz

Figure 5-4. Format of 16-Bit Timer Mode Control Register

|        |   |   |   |   |       |       |       |      |         |          |     |
|--------|---|---|---|---|-------|-------|-------|------|---------|----------|-----|
| Symbol | 7 | 6 | 5 | 4 | 3     | 2     | 1     | 0    | Address | At reset | R/W |
| TMC0   | 0 | 0 | 0 | 0 | TMC03 | TMC02 | TMC01 | OVF0 | FF48H   | 00H      | R/W |

|      |   |  |
|------|---|--|
| OVF0 | Detects overflow of 16-bit timer register |  |
| 0    | Overflow does not occur                   |  |
| 1    | Overflow occurs                           |  |

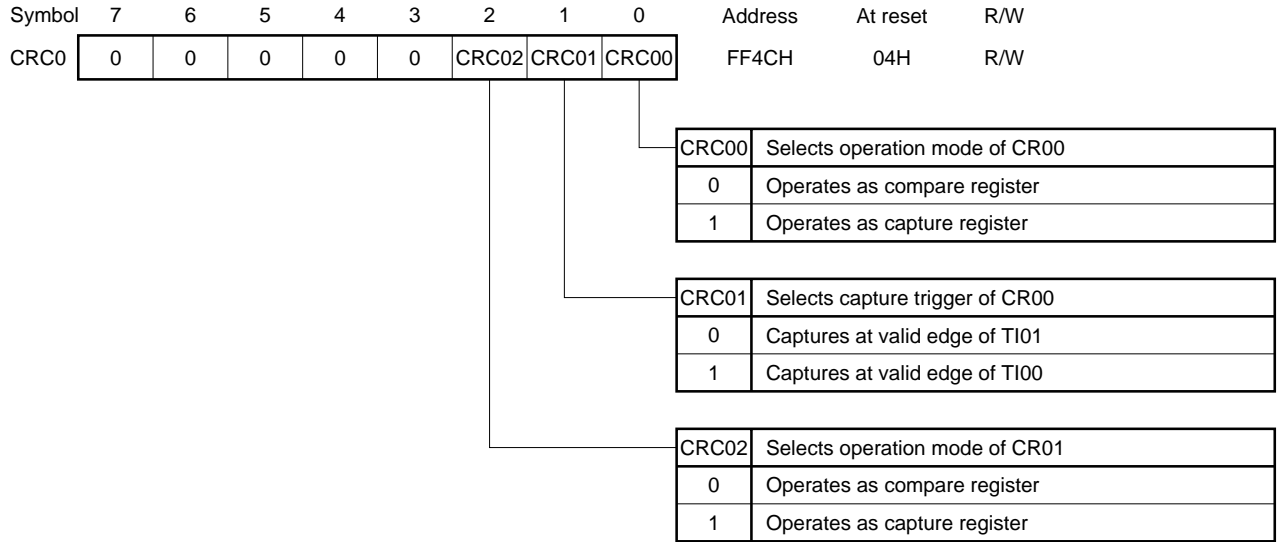
| TMC03 | TMC02 | TMC01 | Selects operation mode and clear mode                | Selects output timing of TO0   | Occurrence of interrupt request                              |
|-------|-------|-------|--|--|--|
| 0     | 0     | 0     | Stops operation (clears TM0 to 0)                    | Not affected   | Does not occur   |
| 0     | 0     | 1     | PWM mode (free running)                              | PWM pulse output   | Occurs if TM0 and CR00 coincide and if TM0 and CR01 coincide |
| 0     | 1     | 0     | Free running mode                                    | Coincidence between TM0 and CR00 or between TM0 and CR01                         |  |
| 0     | 1     | 1     |  | Coincidence between TM0 and CR00, or between TM0 and CR01, or valid edge of TI00 |  |
| 1     | 0     | 0     | Clears and starts at valid edge of TI00              | Coincidence between TM0 and CR00 or between TM0 and CR01                         |  |
| 1     | 0     | 1     |  | Coincidence between TM0 and CR00, or between TM0 and CR01, or valid edge of TI00 |  |
| 1     | 1     | 0     | Clears and start at coincidence between TM0 and CR00 | Coincidence between TM0 and CR00 or between TM0 and CR01                         |  |
| 1     | 1     | 1     |  | Coincidence between TM0 and CR00, or between TM0 and CR01, or valid edge of TI00 |  |

- Cautions**
1. Before setting the clear mode or changing the output timing of TO0, stop the timer operation (by clearing TMC01 through TMC03 to 0, 0, 0).
  2. The valid edge of the TI00/INTP0 pin is selected by the external interrupt mode register 0 (INTM0). The frequency of the sampling clock is selected by the sampling clock select register (SCS).
  3. When using the PWM mode, set data to CR00 after setting the PWM mode.
  4. When a mode in which the timer is cleared and started on coincidence between TM0 and CR00, the OVF0 flag is set to 1 when the set value of CR00 is FFFFH and the value of TM0 changes from FFFFH to 0000H.
  5. The 16-bit timer register starts operating as soon as a value other than 0, 0, 0 (operation stop mode) is set to TMC01 through TMC03. To stop the operation, clear TMC01 through TMC03 to 0, 0, 0.



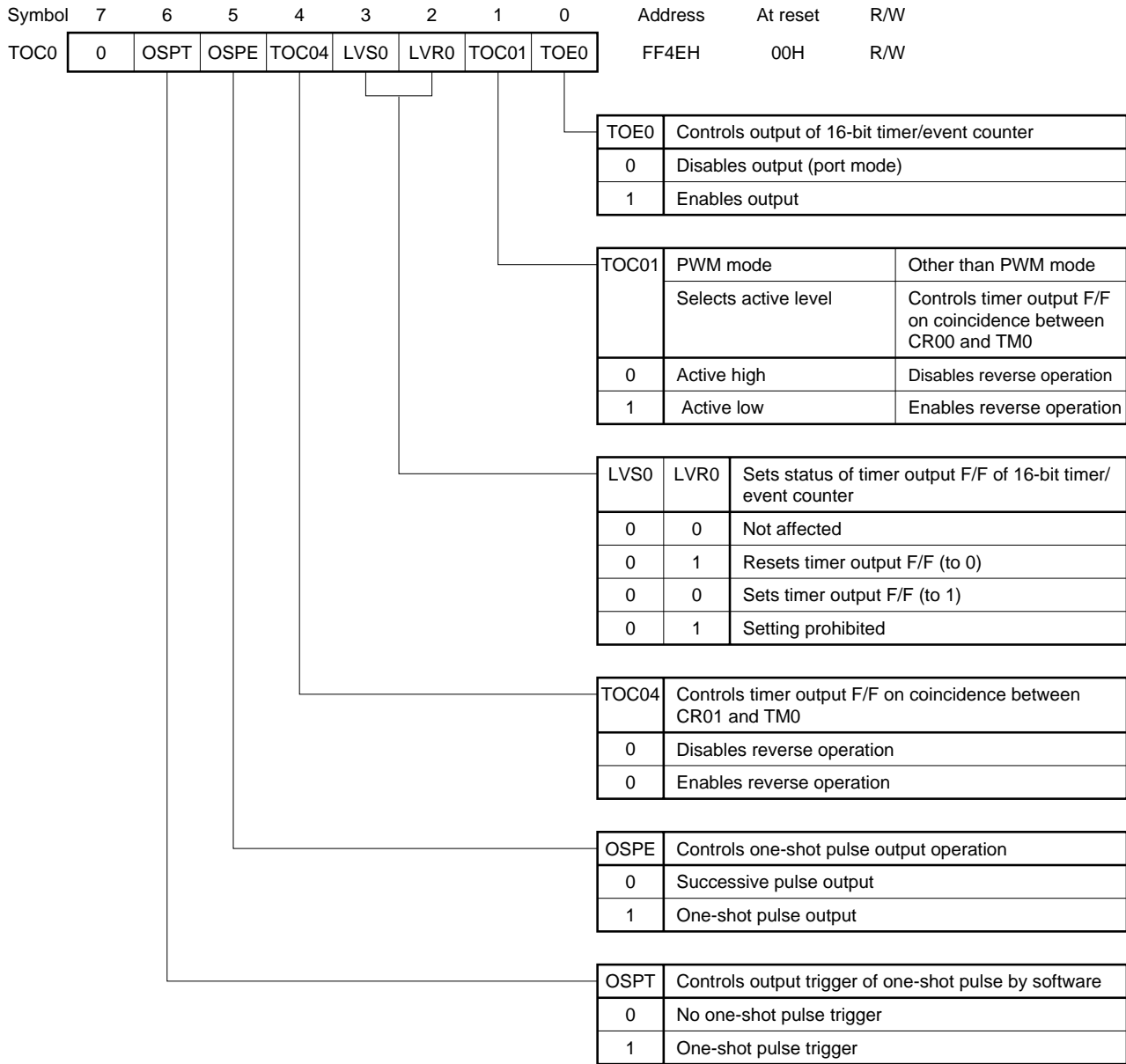
- Remarks**
1. TO0 : output pin of 16-bit timer/event counter
  2. TI00 : input pin of 16-bit timer/event counter
  3. TM0 : 16-bit timer register
  4. CR00 : compare register 00
  5. CR01 : compare register 01

**Figure 5-5. Format of Capture/Compare Control Register**



- Cautions**
1. Be sure to stop the timer operation before setting CRC0.
  2. When a mode in which the timer is cleared and started on coincidence between TM0 and CR00 is selected by the 16-bit timer mode control register, do not specify CR00 as the capture register.

Figure 5-6. Format of 16-Bit Timer Output Control Register



- ★ **Cautions**
1. Be sure to stop the timer operation before setting TOC0 (except OSPT).
  2. LVS0 and LVR0 are always 0 when they are read immediately after data has been set.
  3. OSPT is automatically cleared after data has been set. It is therefore always 0 when read.

Figure 5-7. Format of Port Mode Register 3

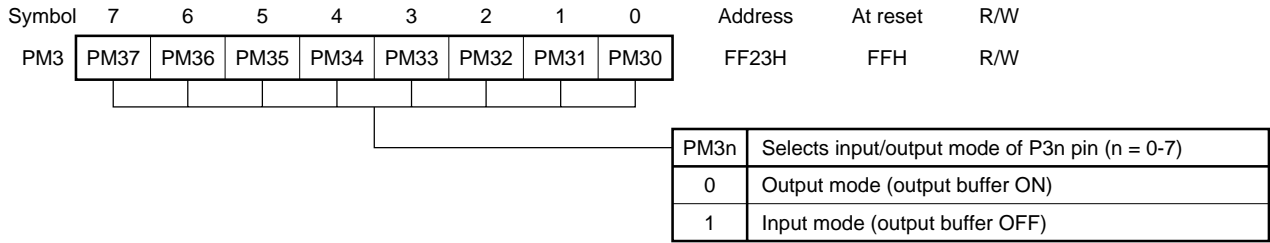
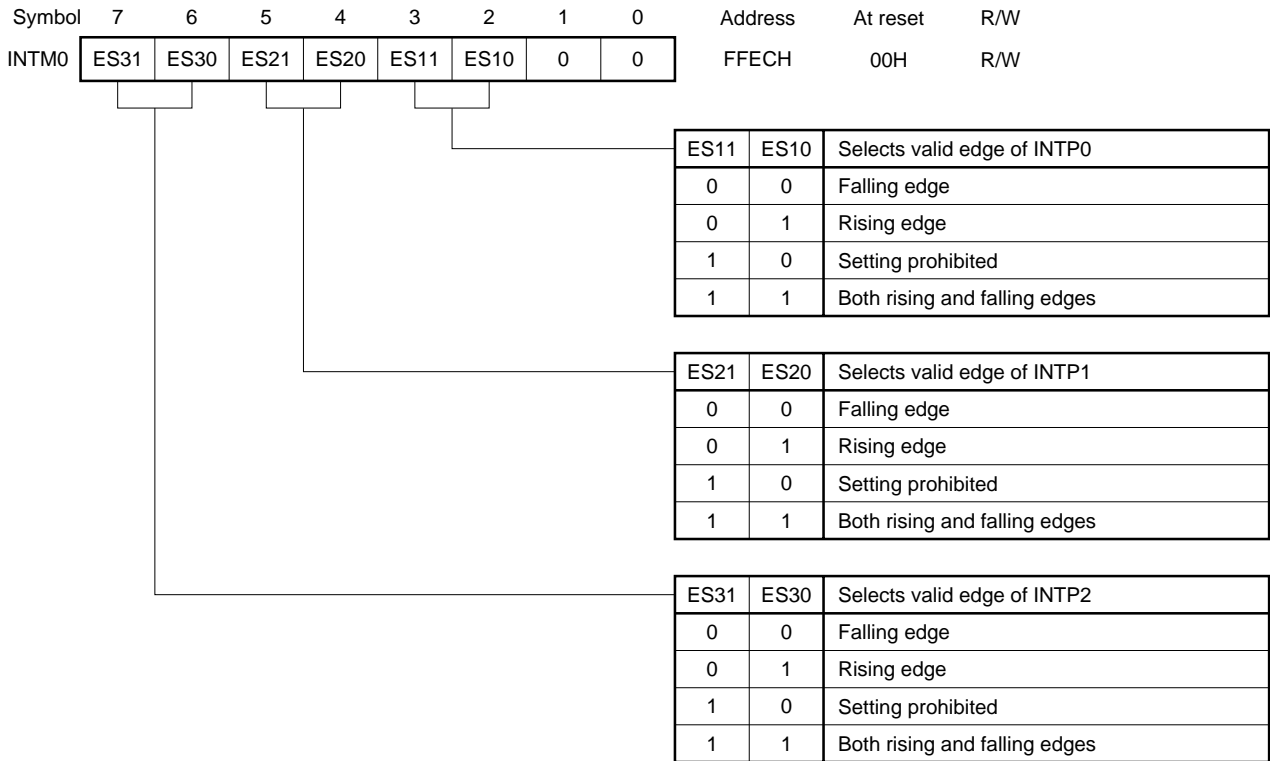


Figure 5-8. Format of External Interrupt Mode Register 0



★ **Caution** Before setting the valid edge of the INTP0/TI00/P00 pin, clear bits 1 through 3 (TMC01 through TMC03) of the 16-bit timer mode control register (TMC0) to 0, 0, 0, and stop the timer.

**Figure 5-9. Format of Sampling Clock Select Register**

( $\mu$ PD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY subseries,  $\mu$ PD78070A, 78070AY)



**Caution**  $f_{xx}/2^N$  is the clock supplied to the CPU, and  $f_{xx}/2^5$ ,  $f_{xx}/2^6$ , and  $f_{xx}/2^7$  are the clocks supplied to the peripheral hardware.  $f_{xx}/2^N$  is stopped in the HALT mode.

- Remarks**
1. N : Value (N = 0 to 4) set to the bits 0 through 2 (PCC0 through PCC2) of the processor clock control register (PCC)
  2.  $f_{xx}$  : main system clock frequency (fx or fx/2)
  3.  $f_x$  : main system clock oscillation frequency
  4. MCS: bit 0 of oscillation mode select register (OSMS)
  5. ( ) : at  $f_x = 5.0$  MHz

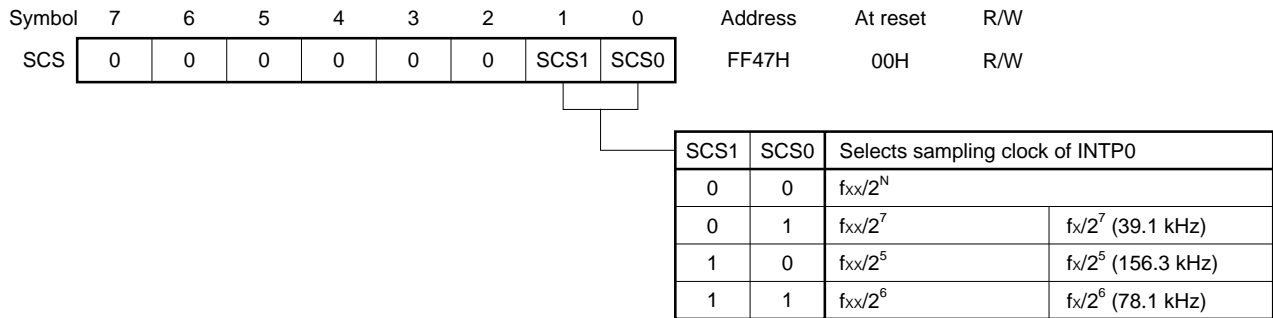
Figure 5-10. Format of Sampling Clock Select Register ( $\mu$ PD78098, 78098B subseries)



**Caution**  $f_{xx}/2^N$  is the clock supplied to the CPU, and  $f_{xx}/2^5$ ,  $f_{xx}/2^6$ , and  $f_{xx}/2^7$  are the clocks supplied to the peripheral hardware.  $f_{xx}/2^N$  is stopped in the HALT mode.

- Remarks 1.** N : Value (N = 0 to 4) set to the bits 0 through 2 (PCC0 through PCC2) of the processor clock control register (PCC)
- 2.**  $f_{xx}$ : main system clock frequency
- 3.** ( ) : at  $f_{xx} = 4.0$  MHz

Figure 5-11. Format of Sampling Clock Select Register ( $\mu$ PD780018, 780018Y subseries)



**Caution**  $f_{xx}/2^N$  is the clock supplied to the CPU, and  $f_{xx}/2^5$ ,  $f_{xx}/2^6$ , and  $f_{xx}/2^7$  are the clocks supplied to the peripheral hardware.  $f_{xx}/2^N$  is stopped in the HALT mode.

- Remarks 1.** N : Value (N = 0 to 4) set to the bits 0 through 2 (PCC0 through PCC2) of the processor clock control register (PCC)
- 2.**  $f_{xx}$ : main system clock frequency (fx)
- 3.** fx : main system clock oscillation frequency
- 4.** ( ) : at fx = 5.0 MHz

## 5.1 Setting of Interval Timer

To set the 16-bit timer/event counter as an interval timer, first set the timer clock select register 0 (TCL0) and the 16-bit timer mode control register (TMC0). The clear mode of the 16-bit timer is set by TMC0 and the interval time is set by TCL0.

After that, set the value of the compare register (CR00) from the setup time and count clock. Determine the setup time by using the following expression:

$$\text{Setup time} = (\text{Compare register value} + 1) \times \text{Count clock cycle}$$

This section shows two examples of setup times of the interval timer: 10 ms and 50 ms.

### (a) Interval of 10 ms

#### <1> Setting of TMC0

Selects a mode in which the timer is cleared and started on coincidence between TM0 and CR00.

#### <2> Setting of TCL0

Select the fxx mode in which an interval time of 10 ms or more can be set and the resolution is the highest (OSMS = 01H).

#### <3> Setting of CR00

$$10 \text{ ms} = (N + 1) \times \frac{1}{4.19 \text{ MHz}}$$

$$N = 10 \text{ ms} \times 4.19 \text{ MHz} - 1 = 4.1899$$

### (1) Program list

OSMS = #00000001B; Does not use divider circuit

CRC0 = #00000000B; Selects CR00 as compare register

CR00 = #41899

TCL0 = #00100000B; Selects count clock fxx

TMC0 = #00001100B; Clears and starts 16-bit timer/event counter when TM0 and CR00 coincide

**(b) Interval of 50 ms****<1> Setting of TMC0**

Selects a mode in which the timer is cleared and started on coincidence between TM0 and CR00.

**<2> Setting of TCL0**

Select the  $f_{xx}/2^2$  mode in which an interval time of 50 ms or more can be set and the resolution is the highest (OSMS = 01H).

**<3> Setting of CR00**

$$50 \text{ ms} = (N + 1) \times \frac{1}{4.19 \text{ MHz}/2^2}$$

$$N = 50 \text{ ms} \times 4.19 \text{ MHz}/2^2 - 1 \doteq 52374$$

**(1) Program list**

OSMS = #00000001B; Does not use divider circuit

CRC0 = #00000000B; Selects CR00 as compare register

CR00 = #52374

TCL0 = #01000000B; Selects count clock  $f_{xx}/2^2$

TMC0 = #00001100B; Clears and starts 16-bit timer/event counter when TM0 and CR00 coincide

## 5.2 PWM Output

When using the 16-bit timer/event counter in the PWM output mode, set the PWM mode by the 16-bit timer mode control register (TMC0) and enables the output of the 16-bit timer/event counter by the 16-bit timer output control register (TOC0).

The pulse width (active level) of PWM is determined by the value set to the capture/compare register 00 (CR00). Because the PWM of the 78K/0 series has a resolution of 14 bits, however, bits 2 through 15 of CR00 are valid (clear bits 0 and 1 of CR00 to '0, 0').

In the example below, the basic cycle of the PWM mode is set to  $61.0 \mu\text{s} \left(\frac{1}{f_{\text{xx}}} \times 2^8\right)$  and the low level is selected as the active level. The high-order 4 bits of the pulse width are rewritten depending on the value of the parameter (00H to FFH). Therefore, in the following application example, PWM output can be performed in 16 steps (CR00 = 0FFCH to FFFCH).

### (1) Description of package

#### <Public declaration symbol>

PWM : PWM output subroutine name  
 PWMOUT: input parameter of PWM active level

#### <Registers used>

AX

#### <RAM used>

| Name   | Usage                 | Attribute | Bytes |
|--------|-----------------------|-----------|-------|
| PWMOUT | Sets PWM active level | SADDR     | 1     |

#### <Nesting>

1 level 2 bytes

#### <Hardware units used>

- 16-bit timer/event counter
- P30/TO0



**<Initial setting>**

- OSMS = #00000001B ; Oscillation mode select register: does not use divider circuit
- Setting of 16-bit timer/event counter
  - CRC0 = #00000000B ; Selects CR00 as compare register
  - TMC0 = #00000010B ; PWM output mode
  - TCL0 = #00100000B ; PWM basic cycle: 61.0  $\mu$ s
  - TOC0 = #00000011B ; Low-active output
- PM30 = 0 ; P30 output mode
- P30 = 0 ; P30 output latch

**<Starting>**

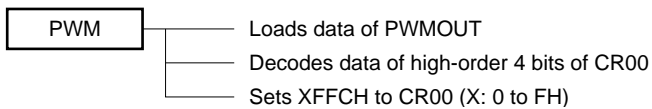
After setting data to PWMOUT in RAM, call subroutine PWM.

**(2) Example of use**

```

EXTRN  PWM, PWMOUT
      :
OSMS = #00000001B ; Does not use divider circuit
CRC0 = #00000000B ; Selects CR00 as compare register
TOC0 = #00000011B ; Sets low-active PWM output
TCL0 = #00100000B ; Selects count clock fxx
TMC0 = #00000010B ; Sets PWM mode
      :
PWMOUT = A ; Sets input parameter of active level
CALL  !PWM
    
```

**(3) SPD chart**



**(4) Program list**

```
        PUBLIC PWM,PWMOUT
PWM_DAT DSEG  SADDR
PWMOUT: DS    1                ; PWM output data area (0-15)
;*****
;*      PWM output (16 steps)
;*****
P0_SEG  CSEG
PWM:
    A=PWMOUT                ; Loads high-order data of PWMOUT
    A<<=1
    A<<=1
    A<<=1
    A<<=1
    A|#0FH                  ; Sets low-order 12 bits to 0FFCH
    X|#0FCH
    CR0=AX
    RET
```

### 5.3 Remote Controller Signal Reception

This section introduces two examples of programs that receives signals from a remote controller by using the 16-bit timer/event counter.

- The counter is cleared each time the valid edge of the remote controller signal has been detected, and measures a pulse width from the timer count value (capture register CR01) when the next valid edge has been detected.
- The timer operates in the free running mode to measure a pulse width from the difference of the counter between valid edges. PWM output is also performed at the same time.

The remote controller signal is received by a PIN receiver diode and is input to the P00/T100/INTP0 pin via receive amplifier  $\mu$ PC1490. Figure 5-12 shows an example of a remote controller signal receiver circuit, and Figure 5-13 shows the format of the remote controller signal.

Figure 5-12. Example of Remote Controller Signal Receiver Circuit

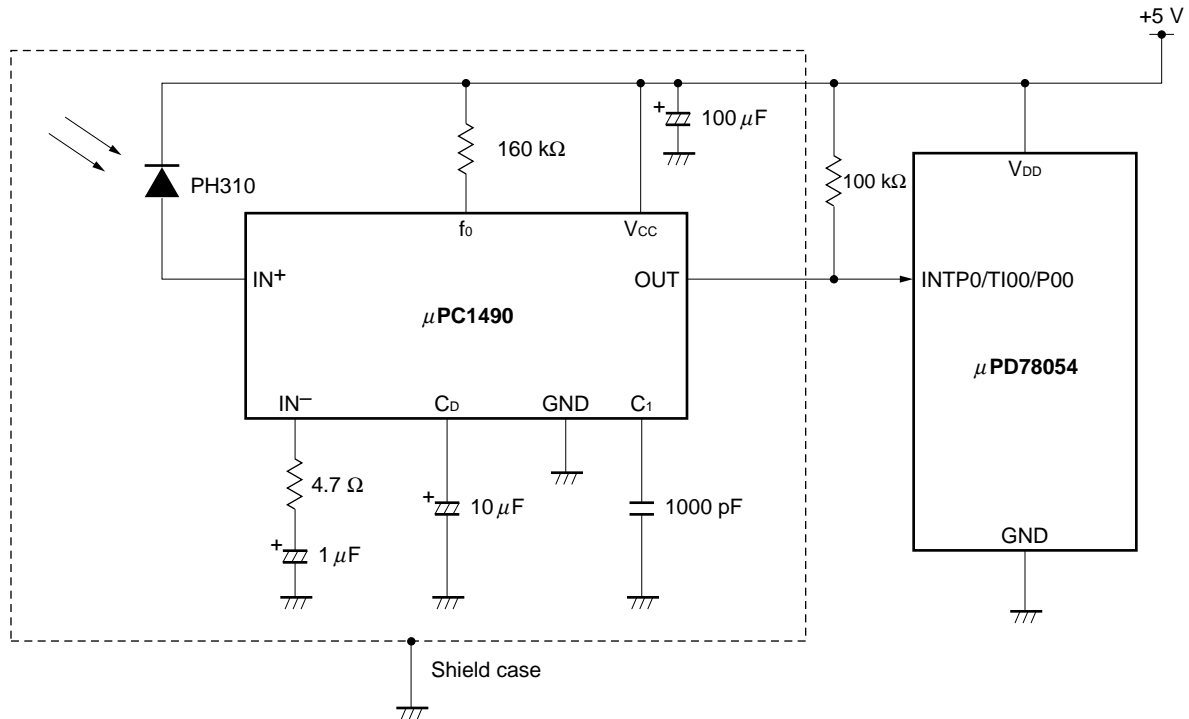
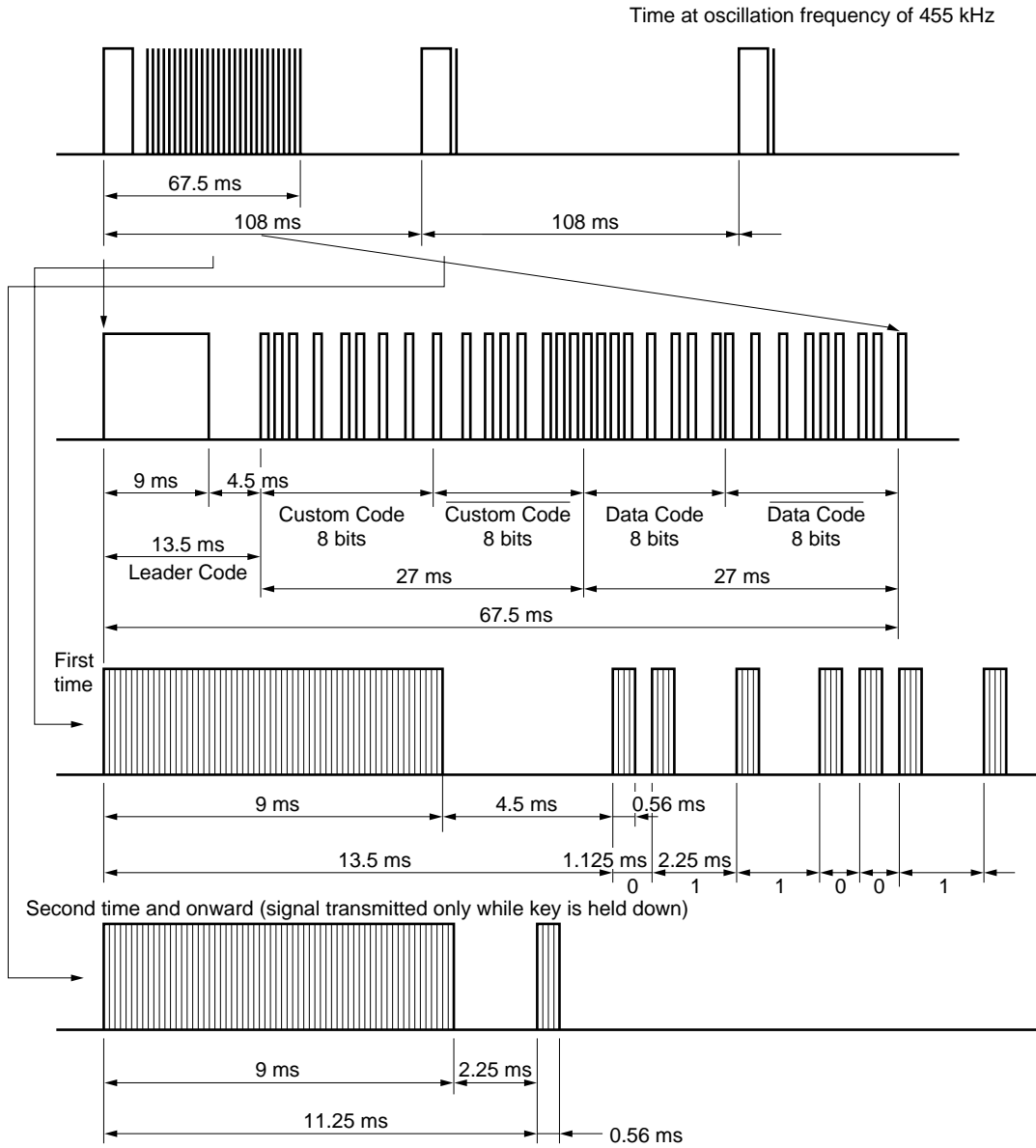
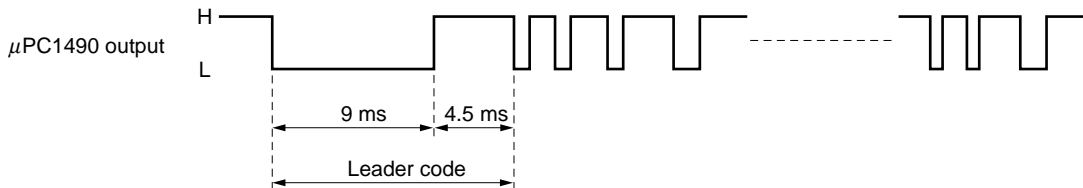


Figure 5-13. Remote Controller Signal Transmitter IC Output Signal



Because the receiver preamplifier  $\mu$ PC1490 used in the circuit example on the previous page is low-active, the level input to the  $\mu$ PD78054 subseries is the inverted data of the remote controller transmit data.

Figure 5-14. Output Signal of Receiver Preamplifier



**5.3.1 Remote controller signal reception by counter clearing**

Table 5-1 shows the valid pulse width for receiving a remote controller signal in the program example shown in this section, and <1> through <6> describes how to process each signal. The repeat signal of the remote controller signal is valid only within 250 ms after a valid signal has been input. If a signal input within 3 ms after the normal data has been loaded, the data is invalid.

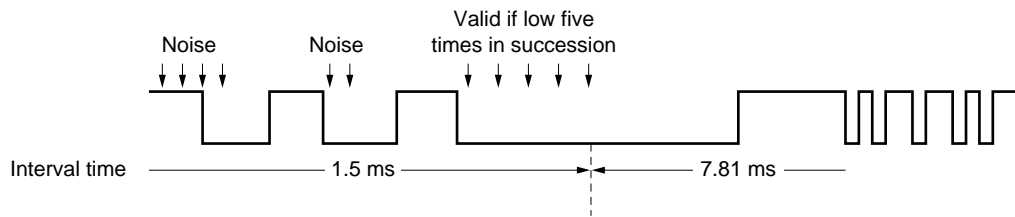
**Table 5-1. Valid Time of Input Signal**

| Signal Name        |        | Output Time | Valid Time     |
|--------------------|--------|-------------|----------------|
| Leader code (low)  |        | 9 ms        | 6.8 ms-11.8 ms |
| Leader code (high) | Normal | 4.5 ms      | 3 ms-5 ms      |
|                    | Repeat | 2.25 ms     | 1.8 ms-3 ms    |
| Custom/data code   | 0      | 1.125 ms    | 0.5 ms-1.8 ms  |
|                    | 1      | 2.25 ms     | 1.8 ms-2.5 ms  |

**<1> Leader code (low)**

The interval time of the 16-bit timer/event counter is set to 1.5 ms, and the port level is sampled by means of interrupt processing. When five low levels have been detected in succession, these low levels are identified as a leader code, and the interval time is changed to 7.81 ms. After that, the pulse width of the low level of the leader code is measured by using rising-edge interrupt request INTPO.

**Figure 5-15. Sampling of Remote Controller Signal**



**<2> Leader code (high)**

The pulse width while the leader code is high is measured by using the falling-edge interrupt request INTP0 and the count value of the timer.

**<3> Custom/data code**

The pulse width of each 1 bit (1 cycle) is measured by using the falling-edge interrupt request INTP0. After the data of the 32nd bit has been loaded, the system tests if the inverted data and custom code coincide. It also checks that there is no data in the 33rd bit.

**<4> Repeat code detection**

When the high level of the leader code is less than 3 ms, the pulse width from output of the leader code to the rising edge of the INTP0 is measured.

**<5> Valid period of repeat code**

After the valid data has been input, sampling is performed by the interrupt processing (1.5 ms interval) of the 16-bit timer/event counter to measure the valid time of the repeat code of 250 ms.

**<6> Time out during pulse width measurement**

If the interrupt request of the 16-bit timer/event counter (7.81 ms) occurs during pulse width measurement, it is judged to be time out, and the data is invalid.

**(1) Description of package****<Public declaration symbol>**

RMDATA : Stores remote controller receive data  
RPT : Repeat valid period identification flag  
IPDTFG : Valid data identification flag  
RMDTOK : Input signal validity identification flag  
RMDTSET: Input signal identification flag

**<Registers used>**

Bank 0: AX, BC, HL

**<RAM used>**

| Name    | Usage                                  | Attribute | Bytes |
|---------|--|-----------|-------|
| RPTCT   | Repeat code valid time counter         | SADDR     | 1     |
| RMENDCT | No-input time counter after data input |           |       |
| SELMOD  | Mode selection                         |           |       |
| LD_CT   | Leader signal detection counter        |           |       |
| RMDATA  | Valid data storage area                |           |       |
| WORKP   | Input signal storage area              | SADDRP    | 4     |

**<Flags used>**

| Name    | Usage  |
|---------|--|
| IPDTFG  | Presence/absence of valid data               |
| RMDTOK  | Validity of input signal                     |
| RMDTSET | Presence/absence of input signal             |
| RPT     | Judgment whether repeat valid period elapsed |

**<Nesting>**

5 levels 12 bytes

**<Hardware used>**

- 16-bit timer/event counter
- P00/TI00/INTP0

**<Initial setting>**

- OSMS = #00000001B ; Oscillation mode select register: does not use divider circuit
- Setting of 16-bit timer/event counter
  - CRC0 = #00000100B ; Selects operation mode of CR00, CR01
  - TMC0 = #00001100B ; Clears timer on coincidence between TM0 and CR00
  - TCL0 = #00100000B ; Count clock  $f_{xx}$
  - CR00 = #6290 ; Compare register 00
- SCS = #00000011B ; INTP0 sampling clock  $f_{xx}/2^6$
- PPR0 = 0 ; INTP0 high-priority interrupt
- TMMK0 = 0 ; Enables 16-bit timer/event counter interrupt
- Defines custom code to be CSTM and declares PUBLIC
- RAM clear

**<Starting>**

Started by INTP0 and INTTM00 interrupt requests

## (2) Example of use

```

PUBLIC  CSTM
EXTRN  RMDATA,RPTCT
EXTBIT  RPT,RMDTSET,IPDTFG

CSTM  EQU    9DH                ; Remote controller custom code

OSMS=#00000001B                ; Does not use divider circuit
CRC0=#00000100B                ; Selects operation mode of CR00, CR01
CR00=#6290
TCL0=#00100000B                ; Sets 1.5 ms
TMC0=#00001100B
SCS=#00000011B                ; fxx/26 as INTP0 sampling clock

CLR1  PPR0                    ; INTP0 with high priority
CLR1  RPT                      ; Clears flag
CLR1  IPDTFG
CLR1  RMDTSET

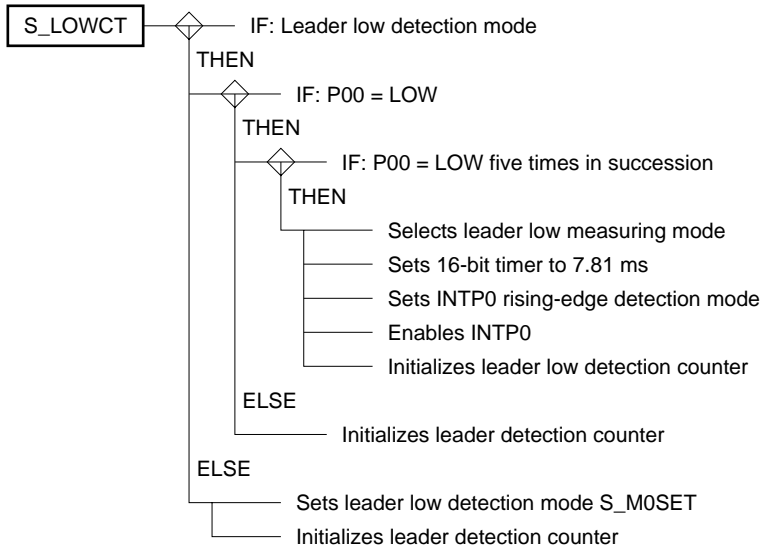
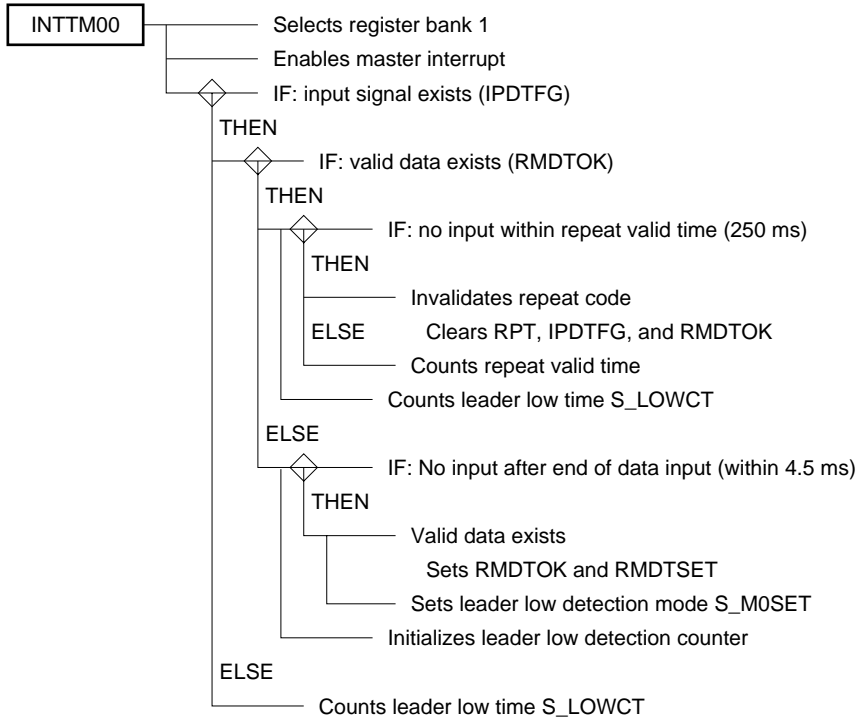
CLR1  TMMK0                    ; Enables timer interrupt
EI

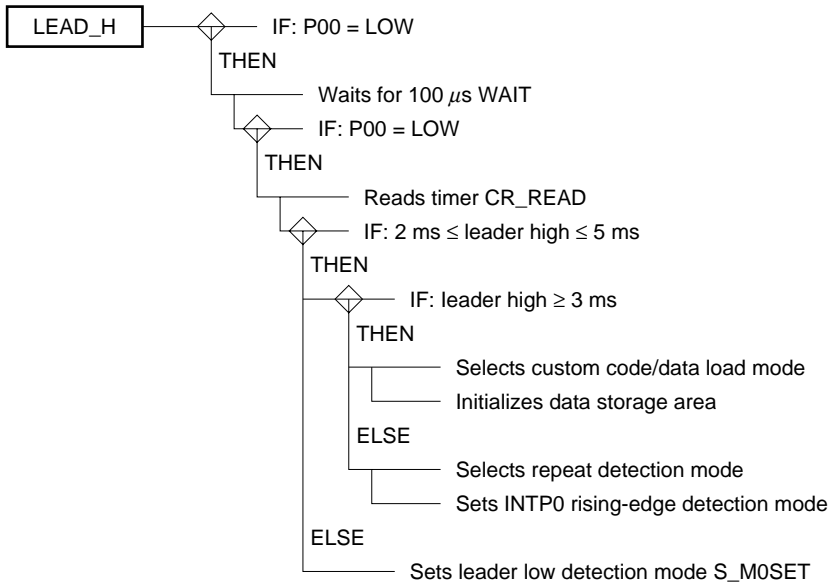
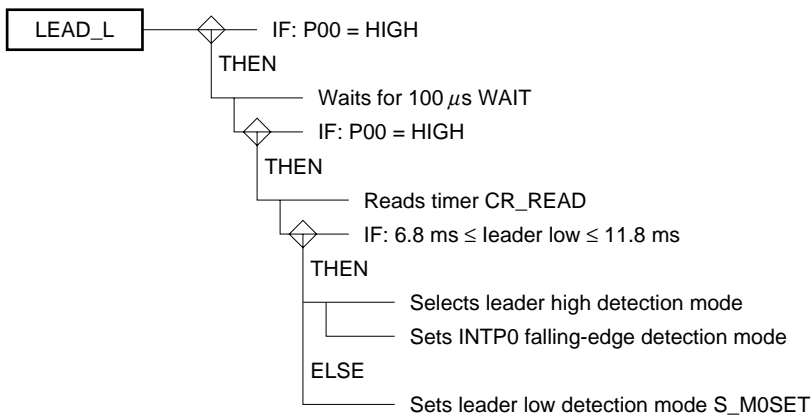
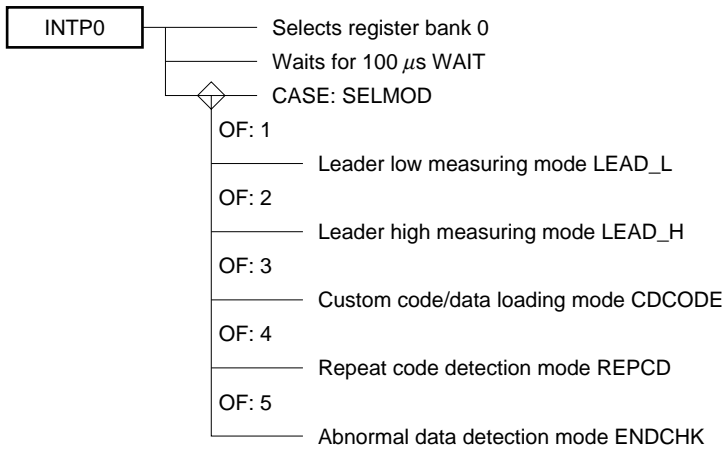
DT_TEST:
    if_bit(RMDTSET)
        CLR1  RMDTSET
        if_bit(RPT)
;
;           Repeat processing
;
        else
;
;           Processing when there is input
;
        endif
    else
        if_bit(!RPT)
;
;           Processing when there is no input
;
        endif
    endif
endif

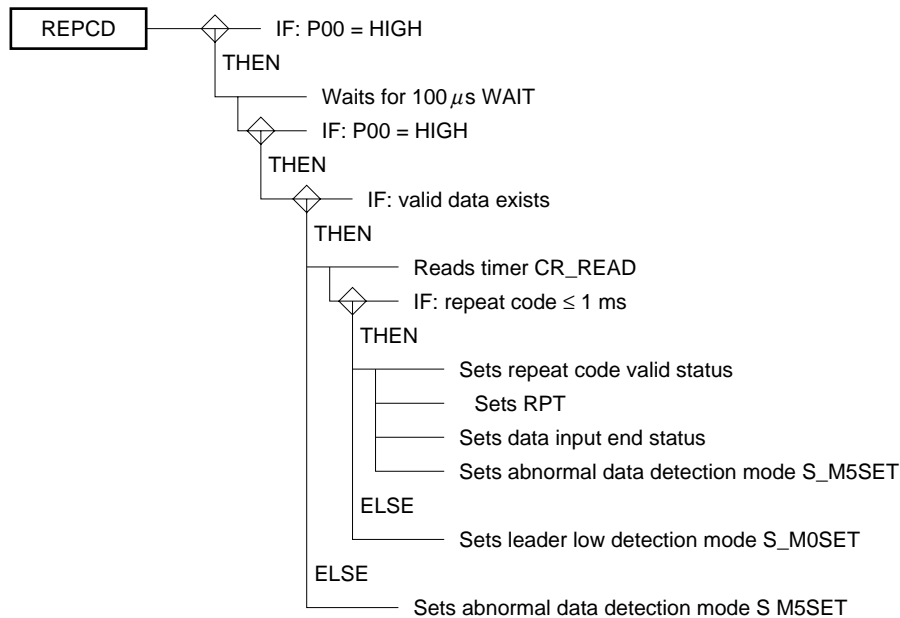
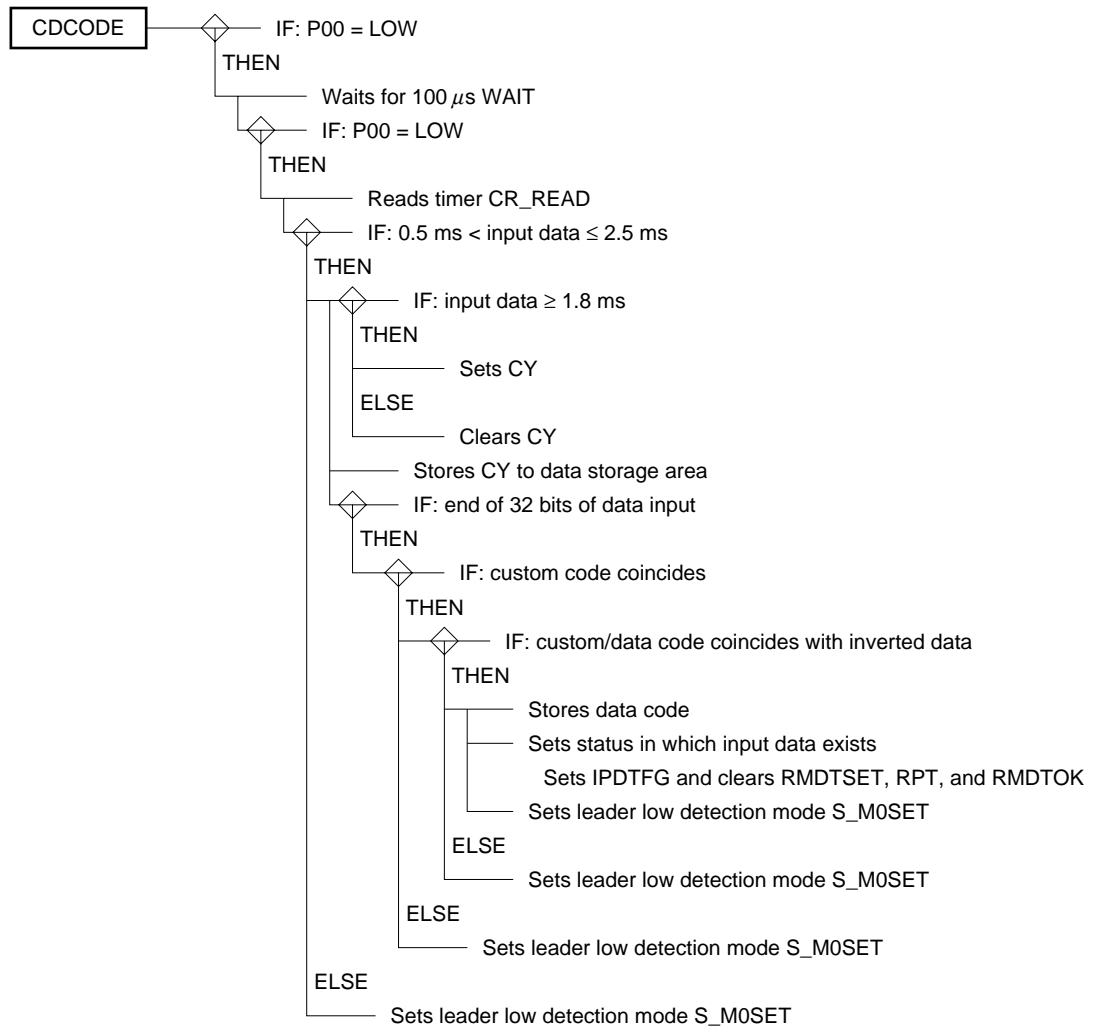
```

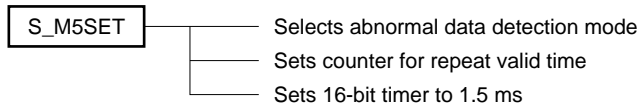
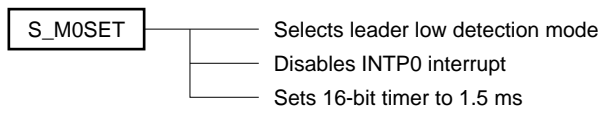
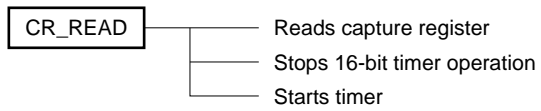
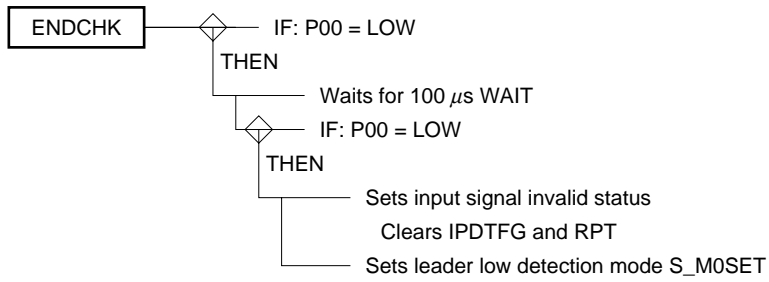


(3) SPD chart









## (4) Program list

```

        PUBLIC RPT , IPDTFG , RMDTOK , RMDTSET
        PUBLIC RMENDCT , RPTCT , SELMOD , LD_CT , RMDATA
        EXTRN  CSTM
RM_DAT  DSEG  SADDR
RPTCT:   DS    1                ; Repeat code valid time counter
RMENDCT: DS    DS              ; No-input time counter after data input
SELMOD:  DS    1                ; Selects mode
LD_CT:   DS    1                ; Leader signal detection counter
RMDATA:  DS    1                ; Valid data storage area

RM_DATP DSEG  SADDRP
WORKP:   DS    4                ; Input signal storage area

        BSEG
IPDTFG  DBIT                    ; Valid data exists
RMDTOK  DBIT                    ; Input signal is valid
RMDTSET DBIT                    ; Input signal exists
RPT     DBIT                    ; Repeat code valid period

VEP0    CSEG  AT 06H
        DW    INTPO              ; Sets vector address of INTPO

VETM0   CSEG  AT 20H
        DW    INTTM00           ; Sets vector address of 16-bit timer

;*****
; Remote controller signal timer processing
;*****
TM0_SEG  CSEG
INTTM00:

        SEL  RB1
        EI                    ; Enables interrupt (INTPO)
        if_bit(IPDTFG)       ; Input signal exists?
            if_bit(RMDTOK)   ; Valid data exists?
                RPTCT--
                if(RPTCT==#0) ; Repeat invalid time
                    CLR1  RPT ; Repeat code invalid status
                    CLR1  IPDTFG
                    CLR1  RMDTOK
                endif
                CALL    !S_LOWCT
            else
                RMENDCT--
                if(RMENDCT==#0)
                    SET1  RMDTOK ; Sets that valid data exists
                    SET1  RMDTSET
                    CALL  !S_M0SET ; Sets leader (low) detection mode
                endif
                LD_CT=#5
            endif
        else
            CALL    !s_LOWCT
        endif
        RETI

```

```

S_LOWCT:
    if (SELMOD==#0)                                ; Leader (low) detection mode?
        if_bit(!P0.0)
            LD_CT--
            if (LD_CT==#0)
                SELMOD=#1                            ; Leader (low) measuring mode
                TMC0=#00000000B
                CR00=#32767                          ; Timer: 7.81 ms
                TMC0=#00001100B
                INTM0=#00000100B
                CLR1 PIF0
                CLR1 PMK0                            ; Enables INTP0 interrupt
                LD_CT=#5
            endif
        else
            LD_CT=#5
        endif
    else
        CALL          !S_MOSET                        ; Sets leader (low) detection mode
        LD_CT=#5
    endif
    RET

$EJECT
;*****
;* Remote controller signal edge detection processing
;*****
P0_SEG CSEG
INTP0:

    SEL      RBO
    CALL     !WAIT                                ; Waits for 100 μs
    switch(SELMOD)
    case 1:
        CALL     !LEAD_L                          ; Leader low detection processing
        break
    case 2:
        CALL     !LEAD_H                          ; Leader high detection processing
        break
    case 3:
        CALL     !CDCODE                          ; Custom/data code loading processing
        break
    case 4:
        CALL     !REPCD                           ; Repeat code detection processing
        break
    case 5:
        CALL     !ENDCHK                          ; Abnormal data detection processing
    ends
    RET1

```

```

;*****
;*      Leader low detection
;*****
LEAD_L:

    if_bit(P0.0)                ; Level check P0.0 = 0: noise
        CALL    !WAIT           ; Waits for 100 μs
        if_bit(P0.0)
            CALL    !CR_READ     ; Reads timer value
            if (AX>=#3354)       ; 6.8 ms – (1.5 ms * 4)
                if (AX<=#18035) ; 11.8 ms – (1.5 ms * 5)
                    SELMOD=#2    ; Leader high detection mode
                    INTM0=#0000000B ; INTP0 falling edge
                else
                    CALL    !S_M0SET ; Sets leader (low) detection mode
                endif
            else
                CALL    !S_M0SET ; Sets leader (low) detection mode
            endif
        endif
    endif
    RET

$EJECT
;*****
;*      Leader high detection
;*****
LEAD_H:

    if_bit(!P0.0)              ; Level check P0.0 = 1: noise
        CALL    !WAIT           ; Waits for 100 μs
        if_bit(!P0.0)
            CALL    !CR_READ     ; Reads timer value
            if (AX>=#6710-160/2) ; 1.8 ms – 100 μs * 2 – 160 clocks (edge detection → timer starts)
                if (AX<=#20132-160/2) ; 5 ms – 100 μs * 2 – 160 clocks (edge detection → timer starts)
                    if (AX>=#11743-160/2) ; Custom/data code (3 ms – 100 μs * 2)?
                        SELMOD=#3    ; Data loading mode
                        WORKP=#0000H ; Initializes work area
                        (WORKP)+2=#8000H ; Sets most significant bit to 1 (to check end of data)
                    else
                        SELMOD=#4    ; Repeat detection mode
                        INTM0=#00000100B ; INTP0 rises
                    endif
                else
                    CALL    !S_M0SET ; Sets leader (low) detection mode
                endif
            else
                CALL    !S_M0SET ; Sets leader (low) detection mode
            endif
        endif
    endif
    RET

$EJECT

```

```

;*****
;* Custom/data code loading
;*****
CDCODE:
    if_bit(!P0.0)                ; Level check P0.0 = 1: noise
        CALL    !WAIT            ; Waits for 100 μs
        if_bit(!P0.0)
            CALL    !CR_READ      ; Reads timer value
            if (AX>=#1257-190/2)  ; 0.5 ms - 100 μs * 2 - 190 clocks (edge detection → timer starts)
                if (AX<#9646-190/2) ; 2.5 ms - 100 μs * 2 -190 clocks (edge detection → timer starts)
                    if (AX>=#6710-190/2) ; 1.8 ms - 100 μs * 2 - 190 clocks (edge detection → timer starts)
                        SET1    CY
                    else
                        CLR1    CY
                    endif
                HL=#WORKP+3      ; Sets work area address
                C=#4            ; Sets number of digits of work area
                WKSHT:
                    A=[HL]      ; Stores 1-bit data
                    RORC        A,1 ; Shifts 1 bit
                    [HL]=A
                    HL--
                    DBNZ        C,$WKSHT ; End of shifting all bits
                    if_bit(CY) ; End of 32-bit input?
                        if (WORKP+0==#CSTM) (A) ; Custom code check
                            A^WORKP+1
                            if (A==#0FFH) ; Custom code inverted data check
                                A=WORKP+2
                                A^=WORKP+3 ; Data code inverted data check
                                if (A==#0FFH)
                                    ; Stores input data
                                    RMDATA=WORKP+2 (A)
                                    ; Sets status in which input data exists
                                    SET1    IPDTFG
                                    CLR1    RMDTSET
                                    CLR1    RPT
                                    CLR1    RMDTOK
                                    CALL    !S_M5SET
                                else
                                    ; Sets leader (low) detection mode
                                    CALL    !S_M0SET
                                endif
                            else
                                    ; Sets leader (low) detection mode
                                    CALL    !S_M0SET
                                endif
                        else
                            CALL    !S_M0SET
                        endif
                    endif
                else
                    CALL    !S_M0SET
                endif
            endif
        endif
    endif

```



```

        endif
    endif
    else
        CALL    !S_M0SET    ; Sets leader (low) detection mode
    endif
    else
        CALL    !S_M0SET    ; Sets leader (low) detection mode
    endif
    endif
endif
endif
RET
$EJECT
;*****
;*      Repeat code detection
;*****
REPCD:
    if_bit(P0.0)           ; Level check P0.0 = 0: noise
        CALL    !WAIT      ; Waits for 100 μs
        if_bit(P0.0)
            if_bit(RMDTOK)  ; Valid data exists?
                CALL    !CR_READ ; Reads timer value
                if (AX<=#3354-190/2) ; 1 ms – 100 μs * 2 – 190 clocks (edge detection → timer starts)
                    SET1    RPT
                    CLR1    RMDTOK ; Input signal check after end of data
                    CLR1    RMDTSET
                    CALL    !S_M5SET
                else
                    CALL    !S_M0SET ; Sets leader (low) detection mode
                endif
            else
                CALL    !S_M0SET    ; Sets leader (low) detection mode
            endif
        endif
    endif
endif
RET
$EJECT

```

```

;*****
;*      Abnormal data detection
;*****
ENDCHK:
    if_bit(!P0.0)                ; Level check P0.0 = 1: noise
        CALL    !WAIT           ; Waits for 100 μs
        if_bit(!P0.0)
            CLR1    IPDTFG       ; Abnormal data input
            CLR1    RPT          ; Input signal invalid
            CALL    !S_M0SET     ; Sets leader (low) detection mode
        endif
    endif
    RET

;*****
;*      Waits for 100 μs
;*****
WAIT:
    B=#(838-14-12-8)/12         ; CALL(14), RET(12), MOV(8)
WAITCT:
    DBNZ    B,$WAITCT          ; Sets 100 μs
    RET                                ; 1 instruction 12 clocks

;*****
;*      Sets leader (low) detection mode
;*****
S_M0SET:
    TMC0=#00000000B
    CR00=#6290
    TCL0=#00100000B           ; Sets timer to 1.5 ms
    TMC0=#00001100B
    SELMOD=#0                 ; Leader (low) detection mode
    SET1    PMK0
    RET

;*****
;*      Sets abnormal data detection mode
;*****
S_M5SET:
    RPTCT=#173                ; 250 ms measuring counter
    SELMOD=#5                 ; Data input end mode
    RMENDCT=#3                ; No-input checking counter
    TMC0=#00000000B          ; Stops operation
    CR00=#6290                ; Sets 1.5 ms
    TMC0=#00001100B
    RET

;*****
;*      Reads timer count value
;*****
CR_READ:
    AX=CR01
    TMC0=#00000000B          ; Stops operation
    TMC0=#00001100B          ; Starts timer
    RET

```

### 5.3.2 Remote controller signal reception by PWM output and free running mode

Table 5-2 shows the valid pulse width when a remote controller signal is received by this program. <1> through <6> below describes how each signal is processed.

**Table 5-2. Valid Time of Input Signal**

| Signal Name           |        | Output Time | Valid Time    |
|-----------------------|--------|-------------|---------------|
| Leader code (low)     |        | 9 ms        | 3 ms-10 ms    |
| Leader code<br>(high) | Normal | 4.5 ms      | 3 ms-5 ms     |
|                       | Repeat | 2.25 ms     | 1.8 ms-3 ms   |
| Custom/data<br>code   | 0      | 1.125 ms    | 0.5 ms-1.8 ms |
|                       | 1      | 2.25 ms     | 1.8 ms-2.5 ms |

#### <1> Leader code (low)

The value of the capture/compare register 01 (CR01) is stored to memory by an interrupt request that occurs when the falling edge of INTP0 is detected.

The pulse width is measured from the difference between the values of CR01 and the capture/compare register 00 (CR00) when the rising edge is generated.

#### <2> Leader code (high)

The pulse width between the high levels of the leader code is measured by the falling-edge interrupt request INTP0 and the count value of the timer.

#### <3> Custom/data code

The pulse width of each 1 bit (1 cycle) is measured by the falling-edge interrupt request INTP0. After the data of the 32nd bit has been loaded, the system tests if the inverted data and custom code coincide. It also checks that there is no data of the 33rd bit.

#### <4> Repeat code detection

When the high level of the leader code is less than 3 ms, the pulse width from output of the leader code to the rising edge of the INTP0 is measured.

#### <5> Valid period of repeat code

After the valid data has been input, the overflow flag (OVF0) of the 16-bit timer/event counter is tested by the main program, and the repeat code valid time of 250 ms is measured.

**<6> Time out during pulse width measurement**

The OVFO of the 16-bit timer/event counter is tested during pulse width measurement. If it is detected two times, time out is assumed and the data is assumed to be invalid.

Because the 16-bit timer/event counter operates in the PWM mode in this example, the remote controller signal is received and, at the same time, PWM output can be performed by linking the program of **5.2 PWM Output**.

**(1) Description of package**

**<Public declaration symbol>**

- TIM\_PRO : name of subroutine processing timer overflow
- RMDATA : stores remote controller receive data
- RPT : repeat valid period identification flag
- IPDTFG : valid data identification flag
- RMDTOK : valid input signal identification flag
- RMDTSET : input signal identification flag
- OVSENS : INTP0 processing timer overflow detection flag

**<Registers used>**

Bank 0: AX, BC, HL

**<RAM used>**

| Name    | Usage                                   | Attribute | Bytes |
|---------|---|-----------|-------|
| RPTCT   | Repeat code invalid time counter        | SADDR     | 1     |
| RMENDCT | No-input time counter after data input  |           |       |
| SELMOD  | Mode selection                          |           |       |
| LD_CT   | Leader signal detection counter         |           |       |
| RMDATA  | Valid data storage area                 |           |       |
| TO_CNT  | Timer overflow detection counter        |           |       |
| CR01_NP | Newest timer count value storage area   | SADDRP    | 2     |
| CR01_OP | Previous timer count value storage area |           |       |
| WORKP   | Input signal storage area               |           |       |

**<Flag used>**

| Name    | Usage   |
|---------|---|
| IPDTFG  | Presence/absence of valid data                  |
| RMDTOK  | Presence/absence of valid input signal          |
| RMDTSET | Presence/absence of input signal                |
| RPT     | Judgment whether repeat valid period elapsed    |
| TO_FLG  | Occurrence of timer overflow                    |
| OVSENS  | Detection of timer overflow by INTP0 processing |

**<Nesting>**

5 levels 11 bytes

**<Hardware used>**

- 16-bit timer/event counter
- P00/TI00/INTP0
- P30/TO0

**<Initial setting>**

- OSMS = #00000001B ; Oscillation mode select register: does not use divider circuit
- Setting of 16-bit timer/event counter
  - CRC0 = #00000100B ; Selects operation mode of CR00, CR01
  - TMC0 = #00000010B ; PWM output mode
  - TCL0 = #00100000B ; PWM basic cycle: 61.0  $\mu$ s
  - TOC0 = #00000011B ; Low-active output
- PM30 = 0 ; P30 output mode
- SCS = #00000011B ; INTP0 sampling clock  $f_{xx}/2^6$
- PPR0 = 0 ; INTP0 high-priority interrupt
- PMK0 = 0 ; Enables INTP0 interrupt
- Defines custom code to CSTM and declares PUBLIC
- RAM clear

**<Starting>**

- Test the OVF0 of the 16-bit timer/event counter. When OVF0 is set, call subroutine TIM\_PRO.
- Start by an interrupt request when the valid edge of the remote controller signal is detected.

## (2) Example of use

```

PUBLIC  CSTM
EXTRN  RMDATA, RPTCT, PWM, PWMOUT, TIM_PRO
EXTBIT  RPT, RMDTSET, IPDTFG, TO_FLG, OVSENS
CSTM   EQU    9DH                ; Custom code

OSMS=#00000001B                ; Does not use divider circuit
CRC0=#00000100B                ; Selects operation mode of CR00, CR01
TOC0=#00000011B                ; PWM output, low active setting
TCL0=#00100000B                ; Selects count clock fxx
TMC0=#00000010B                ; PWM mode, overflow occurs
INTM0=#00000000B              ; INTP0 falling edge
SCS=#00000011B                ; INTP0 sampling clock fxx/26

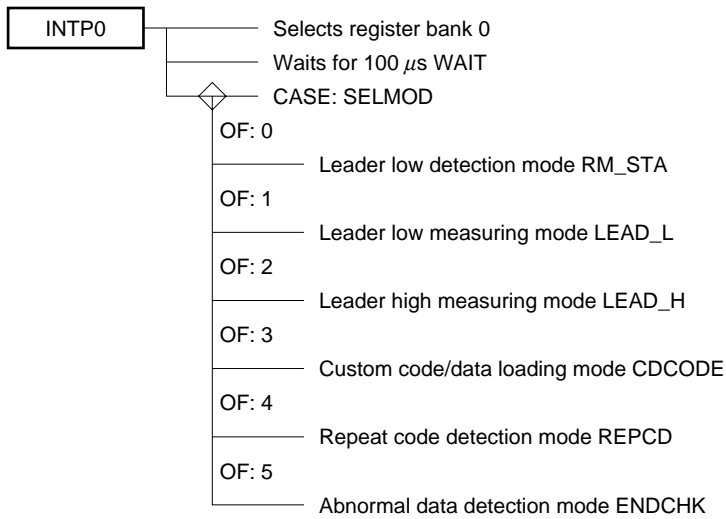
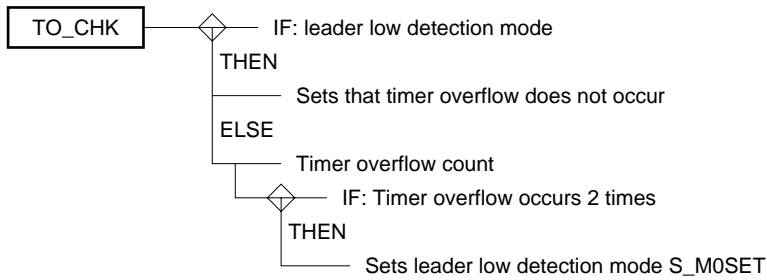
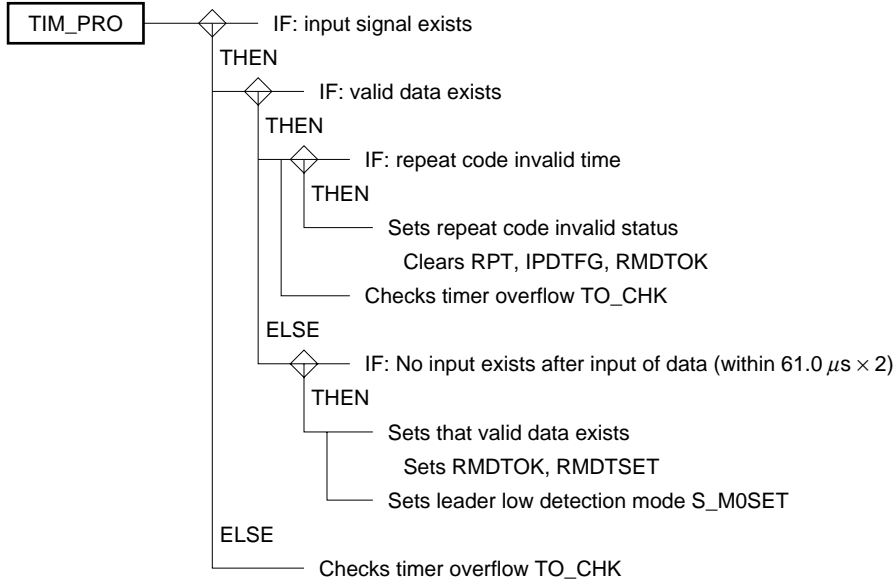
CLR1   PPR0                    ; INTP0 with high priority
CLR1   RPT                     ; Clears flag
CLR1   IPDTFG
CLR1   RMDTSET

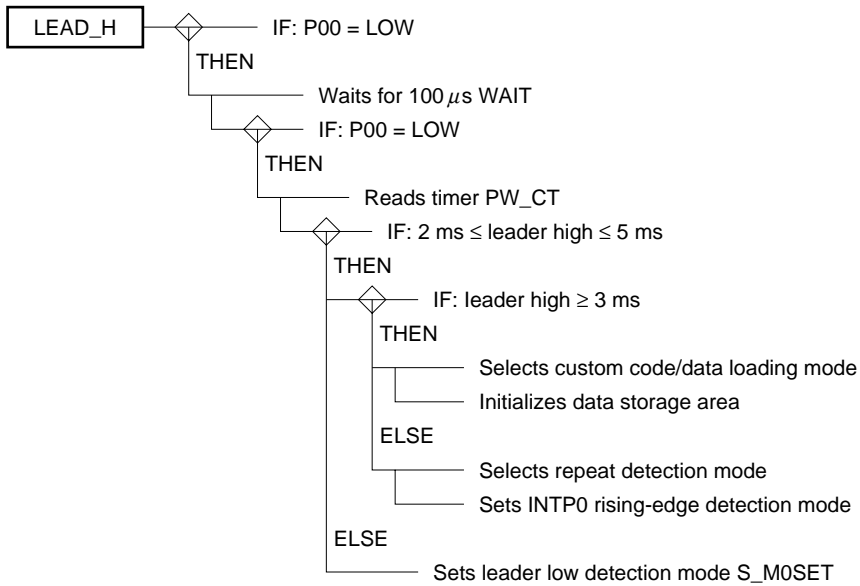
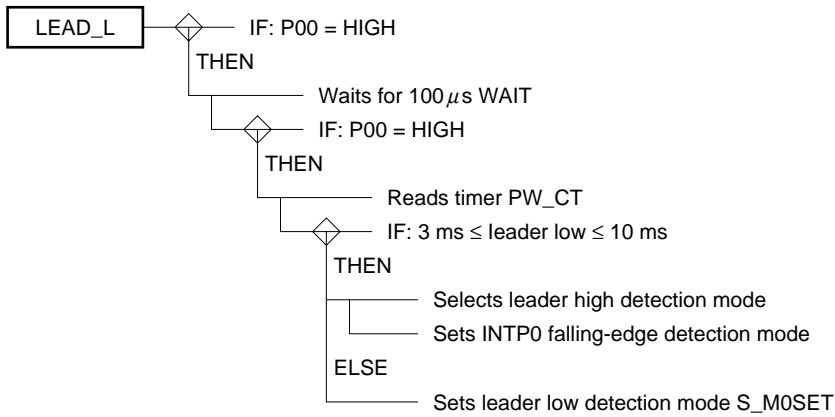
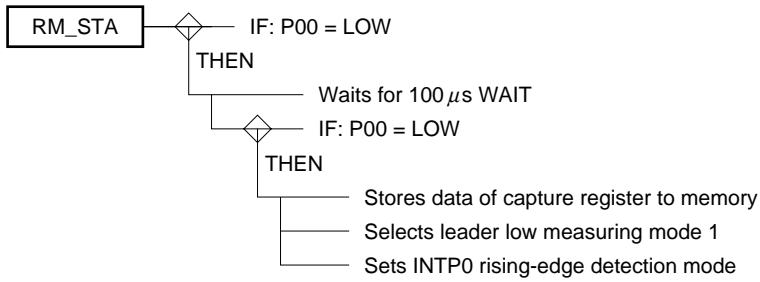
CLR1   PMK0                    ; Enables INTP0 interrupt
EI

DT_TEST:
  if_bit(OVSENS)                ; Detects timer overflow by INTP0 processing
    CLR1  OVSENS
    CALL  !TIM_PRO
  elseif_bit(OVF0)              ; Timer overflow occurs
    CLR1  OVF0
    SET1  TO_FLG
    CALL  !TIM_PRO
  endif
  if_bit(RMDTSET)
    CLR1  RMDTSET
    if_bit(RPT)
;
;           Repeat processing
;
    else
;
;           Processing when input exists
;
    endif
  else
    if_bit(!RPT)
;
;           Processing when input does not exist
;
    endif
  endif
MOV    PWMOUT, A
CALL   !PWM

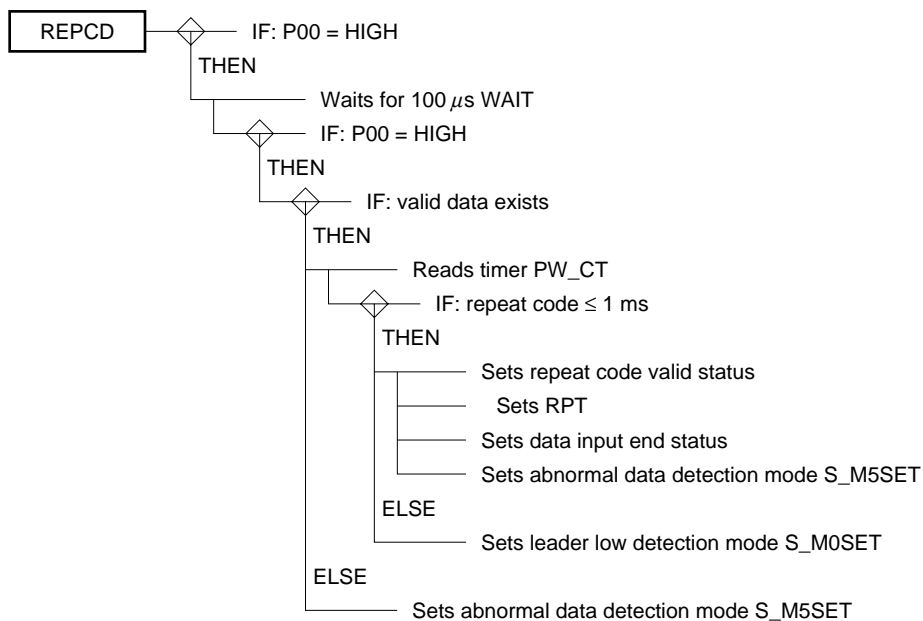
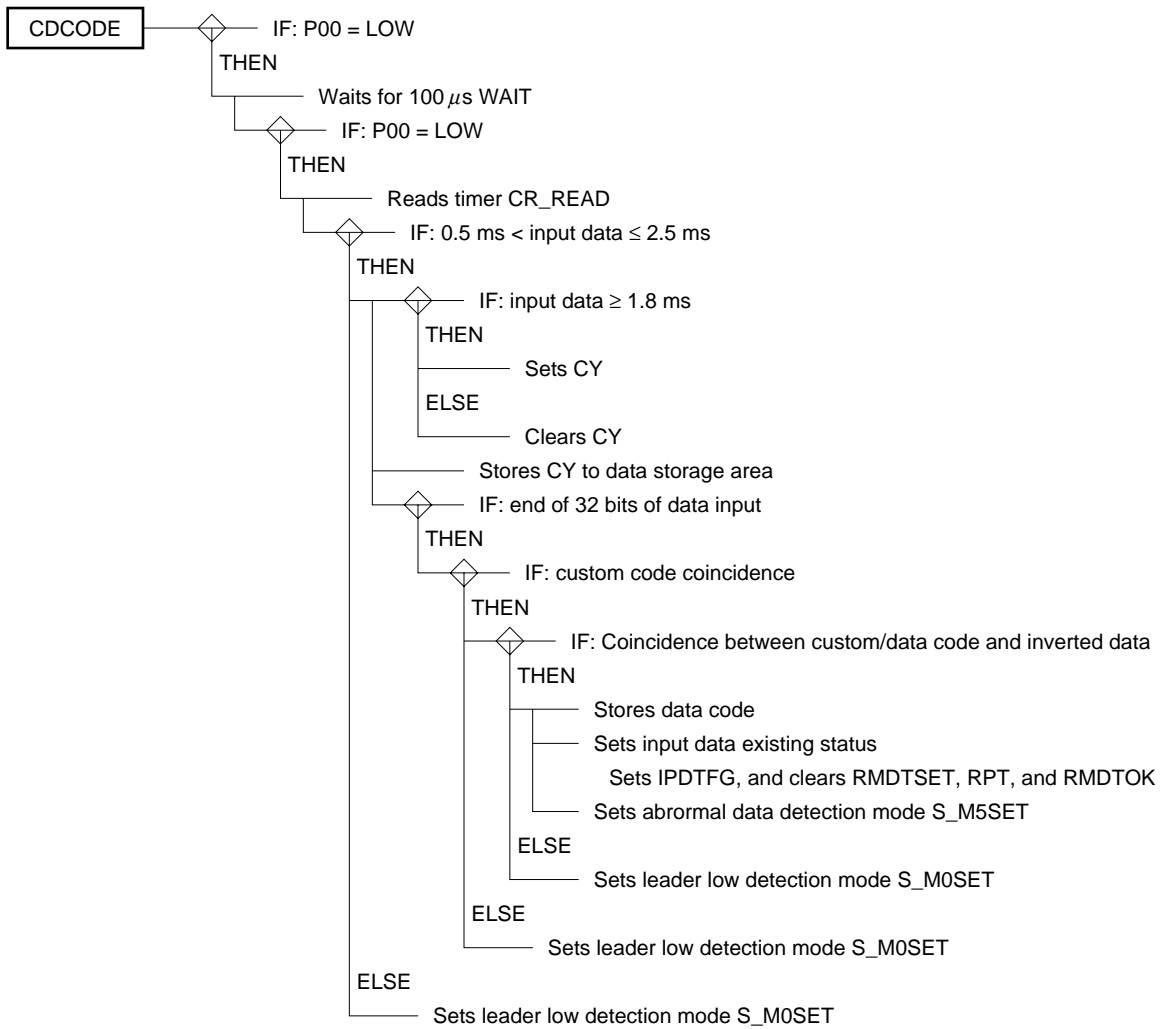
```

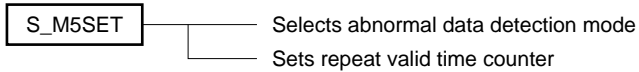
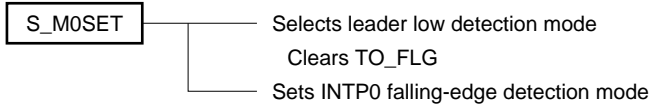
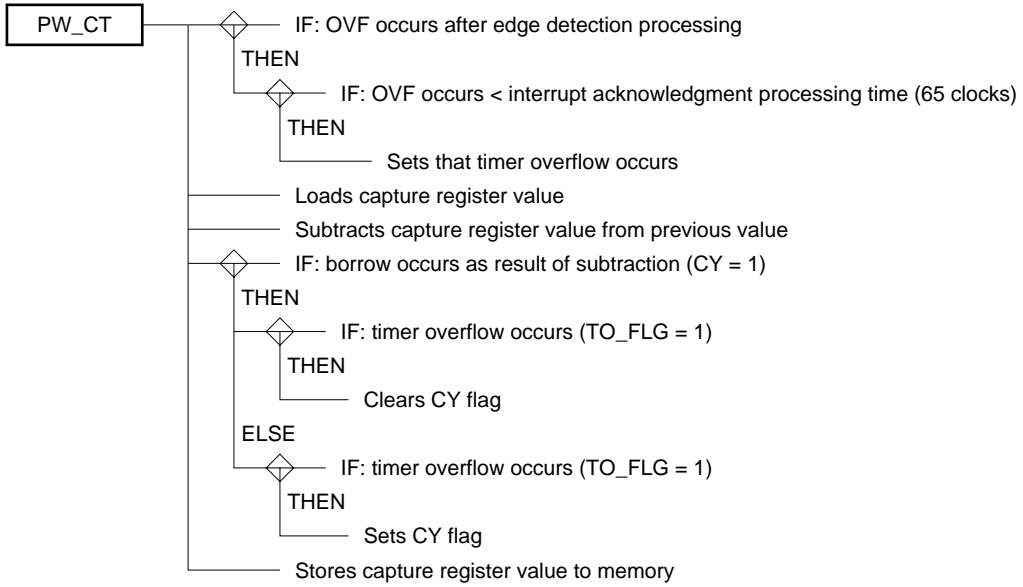
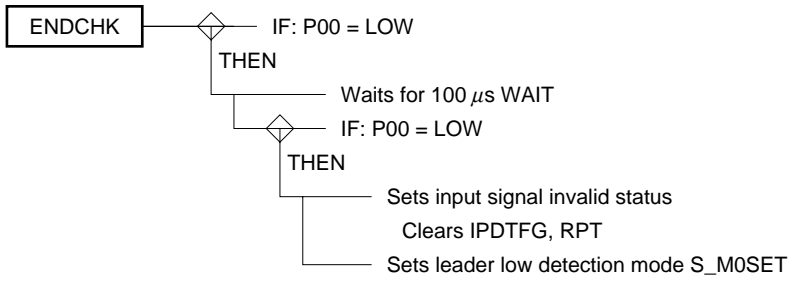
(3) SPD chart











## (4) Program list

```

PUBLIC TIM_PRO, RPT, IPDTFG, RMDTOK, RMDTSET
PUBLIC RMENDCT, RPTCT, SELMOD, LD_CT, RMDATA
PUBLIC TO_FLG, OVSENS
EXTRN  CSTM

RM_DAT  DSEG   SADDR
RPTCT:  DS     1                               ; Repeat code valid time counter
RMENDCT:DS    1                               ; No-input time counter after data input
SELMOD:  DS    1                               ; Mode selection
LD_CT:   DS    1                               ; Leader signal detection counter
RMDATA:  DS    1                               ; Valid data storage area
TO_CNT:  DS    1                               ; Timer overflow counter

RM_DATP DSEG   SADDRP
CR01_NP:DS    2                               ; Newest timer counter value storage area
CR01_OP:DS    2                               ; Previous timer counter value storage area
WORKP:   DS    4                               ; Input signal storage area

        BSEG
IPDTFG  DBIT                               ; Valid data exists
RMDTOK  DBIT                               ; Input signal valid
RMDTSET DBIT                               ; Input signal exists
RPT      DBIT                               ; Repeat code valid period
TO_FLG  DBIT                               ; Timer overflow occurs
OVSENS  DBIT                               ; Detects timer overflow by INTP0 processing

VEP0    CSEG   AT 06H
        DW     INTP0                          ; Sets vector address of INTP0

$EJECT
;*****
; Remote controller signal timer processing
;*****
TM0_SEG CSEG
TIM_PRO:
    if_bit(IPDTFG)                          ; Input signal exists?
        if_bit(RMDTOK)                      ; Valid data exists?
            RPTCT--
            if (RPTCT==#0)                  ; Repeat invalid time
                CLR1  RPT                    ; Repeat code valid status
                CLR1  IPDTFG
                CLR1  RMDTOK
            endif
        else
            RMENDCT--
            if (RMENDCT==#0)
                SET1  RMDTOK                  ; Valid data exists
                SET1  RMDTSET
                CALL  !S_M0SET                ; Sets leader (low) detection mode
            endif
        endif
    else
        CALL  !TO_CHK                          ; Checks timer overflow
    endif
RET

```

```

TO_CHK:
    if (SELMOD==#0)
        CLR1      TO_FLG
    else
        TO_CNT++
        if (TO_CNT==#2)
            CALL      !S_M0SET          ; Sets start edge detection mode
        endif
    endif
    RET
$EJECT
;*****
;*      Remote controller signal edge detection processing
;*****
P0_SEG CSEG
INTP0:
    SEL RB0

    CALL      !WAIT                    ; Waits for 100 μs

    switch(SELMOD)

    case 0:
        CALL      !RM_STA              ; Start edge detection processing
        break
    case 1:
        CALL      !LEAD_L              ; Leader low detection processing
        break
    case 2:
        CALL      !LEAD_H              ; Leader high detection processing
        break
    case 3:
        CALL      !CDCODE              ; Custom/data code loading processing
        break
    case 4:
        CALL      !REPCD               ; Repeat code detection processing
        break
    case 5:
        CALL      !ENDCHK              ; Abnormal data detection processing
    ends
    RET1

;*****
;*      Start edge detection
;*****
RM_STA:
    CLR1      TO_FLG                  ; Starts timer count
    if_bit(!P0.0)                    ; Level check P0.0 = 1: noise
        CALL      !WAIT                ; Waits for 100 μs
        if_bit(!P0.0)
            CR01_OP=CR01 (AX)          ; Stores capture register
            SELMOD=#1                  ; Leader low detection mode
            INTM0=#00000100B          ; INTP0 rising edge
            TO_CNT=#0
        endif
    endif
    RET

```

```

;*****
;*      Leader low detection
;*****
LEAD_L:
    if_bit(P0.0)                ; Level check P0.0 = 1: noise
        CALL    !WAIT           ; Waits for 100 µs
        if_bit(P0.0)
            CALL    !PW_CT       ; Reads timer value
            if_bit(!CY)
                TO_CNT=#0
                if (AX>=#12582)  ; 3 ms
                    if (AX<#41942) ; 10 ms
                        SELMOD=#2 ; Leader high detection mode
                        INTM0=#0000000B ; INTPO falling edge
                    else
                        CALL    !S_M0SET ; Sets start edge detection mode
                    endif
                else
                    CALL    !S_M0SET ; Sets start edge detection mode
                endif
            else
                CALL    !S_M0SET ; Sets start edge detection mode
            endif
        endif
    endif
    RET
$EJECT
;*****
;*      Leader high detection
;*****
LEAD_H:
    if_bit(!P0.0)              ; Level check P0.0 = 0: noise
        CALL    !WAIT           ; Waits for 100 µs
        if_bit(!P0.0)
            CALL    !PW_CT       ; Reads timer value
            if_bit(!CY)
                TO_CNT=#0
                if (AX>=#7549)   ; 1.8 ms
                    if (AX<#20971) ; 5 ms
                        if (AX>#12582) ; Custom/data code (3 ms)?
                            SELMOD=#3 ; Data loading mode
                            WORKP=#0000H ; Initializes work area
                            (WORKP)+2=#8000H ; Sets most significant bit to 1 (to confirm end of data)
                        else
                            SELMOD=#4 ; Repeat detection mode
                            INTM0=#00000100B ; INTPO rises
                        endif
                    else
                        CALL    !S_M0SET ; Sets start edge detection mode
                    endif
                else
                    CALL    !S_M0SET ; Sets start edge detection mode
                endif
            else
                CALL    !S_M0SET ; Sets start edge detection mode
            endif
        endif
    endif
    RET
$EJECT

```

```

;*****
;* Custom/data code loading
;*****
CDCODE:
    if_bit(!P0.0)                ; Level check P0.0 = 1: noise
    CALL    !WAIT                ; Waits for 100 μs
    if_bit(!P0.0)
    CALL    !PW_CT               ; Reads timer value
    if_bit(!CY)
    TO_CNT=#0
    if(AX>=#2096)                ; 0.5 ms
    if(AX<=#10485)              ; 2.5 ms
    if(AX>=#7549)               ; 1.8 ms
    SET1    CY
    else
    CLR1    CY
    endif

    HL=#WORKP+3                 ; Sets work area address
    C=#4                         ; Sets number of work area digits
    WKSHFT:
    A=[HL]                       ; Stores 1-bit data
    RORC    A,1                 ; Shifts 1 bit
    [HL]=A
    HL--
    DBNZ    C,$WKSHFT          ; End of shifting all digits

    if_bit(CY)                  ; End of input of 32 bits?
    ; Checks custom code

    if(WORKP+0==#CSTM) (A)
    A^=WORKP+1
    if(A==#0FFH)                ; Checks custom code inverted data
    A=WORKP+2                    ; Checks data code inverted data
    A^=WORKP+3
    if(A==#0FFH)                ; Stores input data
    RMDATA=WORKP+2 (A)          ; Sets input data existing status
    SET1    IPDTFG
    CLR1    RMDTSET
    CLR1    RPT
    CLR1    RMDTOK
    CALL    !S_M5SET
    else
    ; Sets start edge detection mode
    CALL    !S_M0SET
    endif
    else
    ; Sets start edge detection mode
    CALL    !S_M0SET
    endif
    else
    CALL    !S_M0SET
    endif
    endif
    else
    CALL    !S_M0SET            ; Sets start edge detection mode
    endif
    else

```

```

        CALL    !S_M0SET    ; Sets start edge detection mode
    endif
else
    CALL    !S_M0SET    ; Sets start edge detection mode
endif
endif
endif
RET
$EJECT

;*****
;*      Repeat code detection
;*****
REPCD:
    if_bit(P0.0)                ; Level check P0.0 = 1: noise
        CALL    !WAIT            ; Waits for 100 μs
        if_bit(P0.0)
            if_bit(RMDTOK)        ; Valid data?
                CALL    !PW_CT    ; Reads timer value
                if_bit(!CY)
                    TO_CNT=#0
                    if(AX<=#4193) ; 1 ms
                        SET1    RPT
                        CLR1    RMDTOK    ; Checks input signal after end of data
                        CLR1    RMDTSET
                        CALL    !S_M5SET
                    else
                        CALL    !S_M0SET    ; Sets start edge detection mode
                    endif
                else
                    CALL    !S_M0SET    ; Sets start edge detection mode
                endif
            else
                CALL    !S_M0SET    ; Sets start edge detection mode
            endif
        endif
    endif
endif
RET
$EJECT

```

```

;*****
;*      Abnormal data detection
;*****
ENDCHK:
    if_bit(!P0.0)                ; Level check P0.0 = 1: noise
        CALL    !WAIT            ; Waits for 100 μs
        if_bit(!P0.0)
            CLR1    IPDTFG        ; Abnormal data input
            CLR1    RPT           ; Input signal invalid
            CALL    !S_M0SET      ; Sets start edge detection mode
        endif
    endif
    RET

;*****
;*      Calculation of capture register value
;*****
PW_CT:
    if_bit(OVF0)                ; OVF0 after edge detection?
        if(CR01<#10000-33) (AX) ; Interrupt acknowledgment processing time = 65 clocks (MAX)
            CLR1    OVF0
            SET1    OVSENS
            SET1    TO_FLG
        endif
    endif

    CR01_NP=CR01 (AX)           ; Loads capture register value

    A=CR01_NP+0                ; AX = CR01_NP - CR01_OP
    A-=CR01_OP
    X=A
    A=CR01_NP+1
    SUBC    A,CR01_OP+1

    BC=AX                      ; Saves operation result
    if_bit(CY)                  ; CR01_NP > CR01_OP
        if_bit(TO_FLG)         ; Timer overflow occurs (flag test)
            CLR1    CY          ; Normal data
        endif
    else
        if_bit(TO_FLG)         ; Timer overflow
            SET1    CY          ; Error occurs
        endif
    endif

    CR01_OP=CR01_NP (AX)
    AX=BC                      ; Restores operation result
    CLR1    TO_FLG
    RET

```



```
;*****
;*          Waits for 100  $\mu$ s
;*****
WAIT:
    B=#(838-14-12-8)/12                ; CALL (14), RET (12), MOV (8)
WAITCT:                                ; Sets 100  $\mu$ s
    DBNZ  B,$WAITCT                    ; 1 instruction 12 clocks
    RET

;*****
;*          Sets start edge detection mode
;*****
S_M0SET:
    TO_CNT=#0
    SELMOD=#0                          ; Start edge detection mode
    INTM0=#00000000B                  ; INTPO falling edge
    RET

;*****
;*          Setting of abnormal data detection mode
;*****
S_M5SET:
    RPTCT=#16                          ; 250 ms measuring counter
    SELMOD=#5                          ; Data input end mode
    RMENDCT=#2                         ; No-input checking counter
    RET
```

## 5.4 One-Shot Pulse Output

The 16-bit timer/event counter has a function which outputs a one-shot pulse in synchronization with a software trigger and external trigger (INTP0/TI00/P00 pin input).

When using the one-shot pulse output function, the 16-bit timer mode control register (TMC0), capture/compare control register 0 (CRC0), and 16-bit timer output control register (TOC0) must be set.

In this section, an example for setting the one-shot pulse by using the software trigger is introduced.

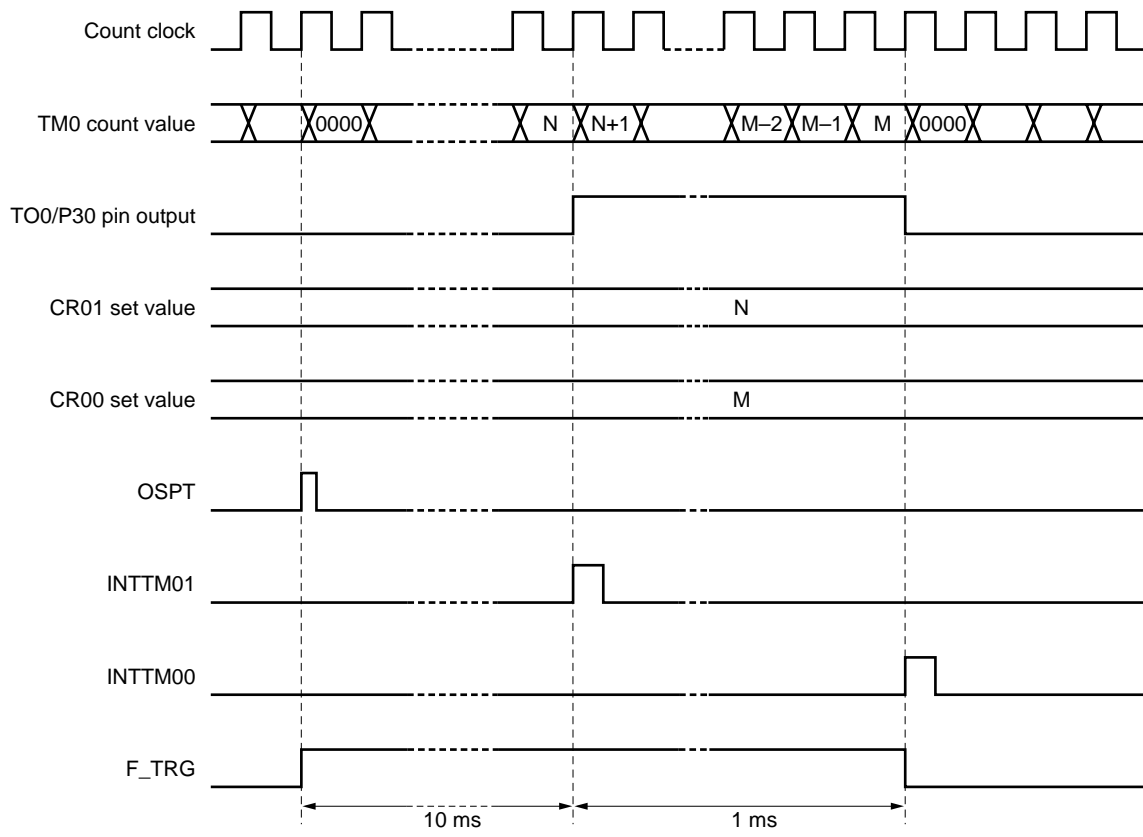
The OSPT flag (bit 6 of the TOC0 register) is set at arbitrary timing (such as key input).

After the software trigger has occurred, TM0 is cleared and started. When the value of TM0 coincides with the value set in advance to CR01, the TO0/P30 pin output is inverted (and becomes active). When the value of TM0 later coincides with the value set in advance to CR00, the TO0/P30 pin output is inverted again (and becomes inactive). The TM0 counter is cleared and counting up is started again after the value of TM0 has coincided with the value of CR00. The output of the TO0/P30 pin, however, is not inverted even if coincidence occurs next time. TM0 is cleared and started and the output of the TO0/P30 pin is inverted only when the software trigger is set. The active level of the TO0/P30 pin is determined by selecting the initial value of the TO0/P30 pin output of the TOC0 register.

Note that, when using the one-shot pulse output function with the software trigger, the OSPT flag must not be set to 1 while the one-shot pulse is output. To output the one-shot pulse again, do so after INTTM00, which is an interrupt request that occurs when TM0 coincides with CR00, has occurred.

In the example presented in this section, the software trigger is designed by using key input, and “H” active output is produced 10 ms after for 1 ms.

Figure 5-16. Timing of One-Shot Pulse Output Operation by Software Trigger



**Remark** F\_TRG: flag indicating that output of the one-shot pulse is in progress. For details, refer to **(2) Example of use.**

**(1) Description of package****<Public declaration symbol>**

SOP\_INIT: One-shot pulse output initial setting subroutine

**<Register used>**

None

**<RAM used>**

None

**<Nesting level>**

1 level 2 bytes

**<Hardware used>**

- 16-bit timer/event counter

**<Initial setting>**

- OSMS = #00000001B; Oscillation mode select register: does not use divider circuit
- CLR1 P3.0 ; Clears output latch of bit 0 of port 3 to 0
- CLR1 PM3.0 ; Sets bit 0 of port mode register 3 in output mode
- CALL !SOP\_INIT; Sets by subroutine SOP\_INIT

**<Starting>**

Set bit 6 (OSPT) of the 16-bit timer output control register (TOC0).

**(2) Example of use**

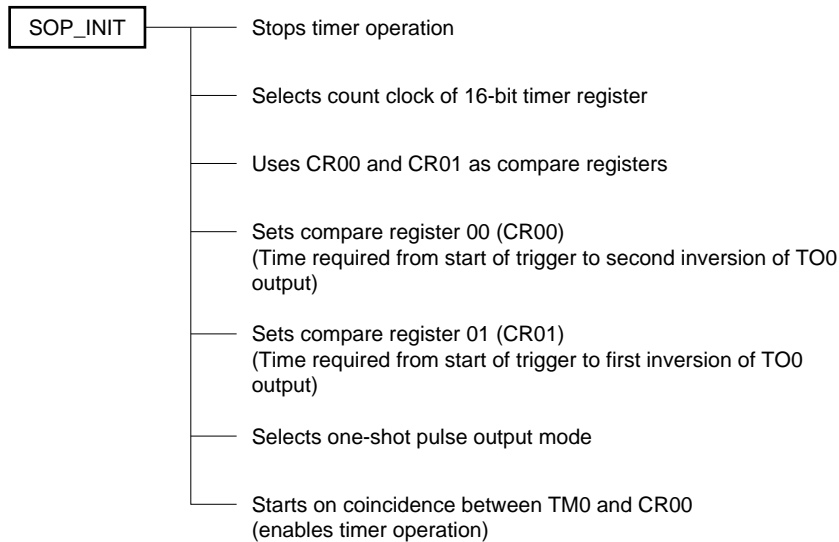
Because bit 6 (OSPT) of the 16-bit timer output control register (TOCR0) is not set again while the pulse is output in the example of this package, the F\_TRG flag is set as soon as the OSPT flag has been set as shown in Figure 5-16. Even if the next output request is issued while the F\_TRG flag is set (i.e., while the pulse is output), the OSPT flag is not set. After the one-shot pulse has been output (INTTM00 occurs), clear the F\_TRG flag.

```

EXTRN  SOP_INT

M1PR0      CSEG
RES_STA:
  OSMS=#00000001B      ; Does not use divider circuit
  CLR1   P3.0          ; Sets 0 to output latch if multiplexed pin is used
  CLR1   PM3.0         ; Sets output mode if multiplexed pin is used
  CALL   !SOP_INIT     ; One-shot pulse output initial setting routine
  .
  .
  if(key request issued)
    if_bit(!F_TRG)      ; Previous output ends?
      SET1   OSPT       ; Clears and starts 16-bit counter
      SET1   F_TRG     ; Sets one-shot pulse trigger flag
    endif
  endif
  if_bit(TMIF00)       ; End of one-shot pulse output?
    CLR1   F_TRG      ; Clears one-shot trigger flag
    CLR1   TMIF00     ; Clears TMIF00 request flag
  endif
  .
  .

```

**(3) SPD chart**

**(4) Program list**

```

PUBLIC SOP_INIT

OPINIT      CSEG
SOP_INIT:
    TMC0=#00000000B      ; Stops timer operation
    TCL0=#01000000B      ; Count clock of 16-bit timer register: 1.05 MHz
    CRC0=#00000000B      ; Uses CR00 and CR01 as compare registers
    CR00=#11550-1        ; Sets compare register to 11 ms
    CR01=#10500-1        ; Sets compare register to 10 ms
    TOC0=#00110111B      ; Selects one-shot pulse mode
    TMC0=#00001100B      ; Starts on coincidence between TM0 and CR00 (enables timer operation)
    RET                  ;
    END

```

**5.5 PPG Output**

When using the 16-bit timer/event counter in the PPG (Programmable Pulse Generator) mode, the 16-bit timer mode control register (TMC0), capture/compare control register 0 (CRC0), and 16-bit timer output control register (TOC0) must be set.

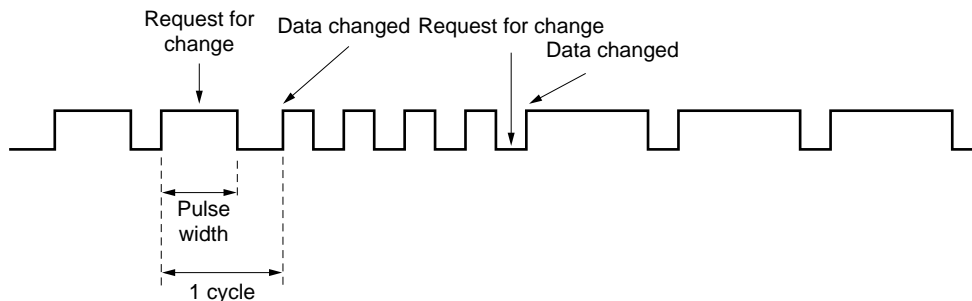
As the PPG output pulse, a square wave with a cycle specified by the count value set in advance to the 16-bit capture/compare register 00 (CR00) and a pulse width specified by the count value set in advance to the 16-bit capture/compare register 01 (CR01) is output from the TO0/P30 pin.

In the application example shown in this section, the output waveform is changed by using the PPG output. Data indicating the one cycle and pulse width of the output waveform is stored in ROM. This data is stored in the compare register.

The cycle and pulse width of the PPG output in this program can be changed in units of 1 ms to 10 ms. Therefore, the cycle can be set in a range of 2 to 10 ms, and the pulse width can be set in a range of 1 to 9 ms. If the cycle is equal to or less than the pulse width when the output waveform is changed, the data is not changed.

The output waveform is changed after the end of one output cycle. Figure 5-17 shows the PPG output waveform changing timing.

**Figure 5-17. PPG Output Waveform Changing Timing**



**(1) Description of package****<Public declaration symbol>**

- Subroutine name  
SPG\_INIT : PPG output initial setting subroutine
- Data definition reference name of SPG\_INIT routine  
PDAT : First address of data value for pulse width stored to compare register  
SDAT : First address of data value for cycle stored to compare register
- Input parameter of SPG\_INIT routine  
PARUSU : Pulse width time storage area  
SAIKURU : 1 cycle time storage area
- Input/output parameters of SPG\_INIT routine and INTTM00 interrupt  
PARUSUP : Pulse width time change data storage area  
SAIKURUP : 1-cycle time change data storage area

**<Registers used>**

- SPG\_INIT : Bank 0 AX, HL  
INTTM00 : Bank 2 AX

**<RAM used>**

| Name     | Usage   | Attribute | Bytes |
|----------|---|-----------|-------|
| PARUSU   | Sets pulse width time                                     | SADDR     | 1     |
| SAIKURU  | Sets 1-cycle time   | SADDR     | 1     |
| PARUSUP  | Sets compare data value corresponding to pulse width time | SADDRP    | 2     |
| SAIKURUP | Sets compare data value corresponding to 1 cycle time     | SADDRP    | 2     |

**<Flag used>**

None

**<Nesting level>**

1 level 3 bytes

**<Hardware used>**

- 16-bit timer/event counter

**<Initial setting>**

- OSMS = #00000001B; Oscillation mode select register: does not use divider circuit
- CLR1 P3.0 ; Clears output latch of bit 0 of port 3 to 0
- CLR1 PM3.0 ; Sets bit 0 of port mode register 3 in output mode
- CALL !PPG\_INIT ; Sets by subroutine PPG\_INIT

**<Starting>**

After the 16-bit timer/event counter has been reset and started, set pulse width time in the specified range to PARUSU in RAM and cycle time in the specified range to SAIKURU, and call subroutine PPG\_INIT. When changing the PPG output waveform, clear the INTTM00 interrupt request flag to enable the interrupt after setting a compare data value corresponding to the pulse width in the specified range to PARUSUP, and a compare data value corresponding to the cycle time in the specified range to SAIKURUP.



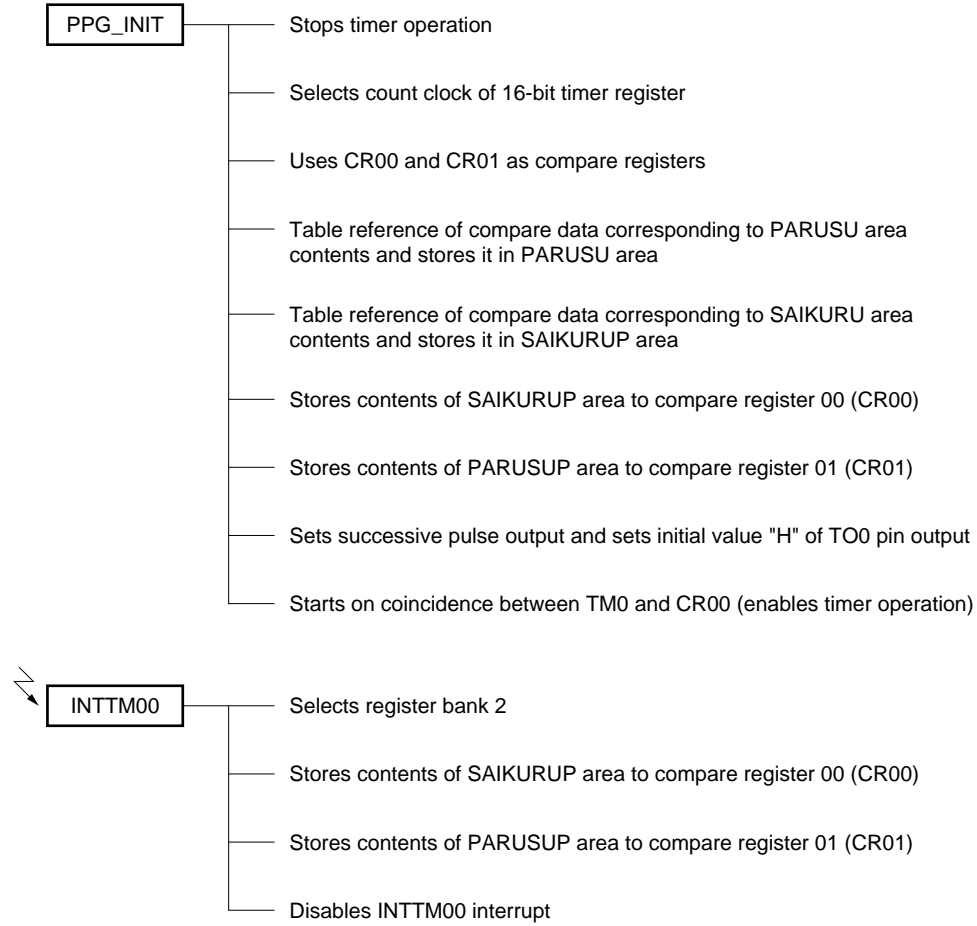
## (2) Example of use

```

EXTRN  SPG_INIT
EXTRN  SAIKURUP.PARUSUP
EXTRN  SAIKURU,PARUSU
EXTRN  PDAT,SDAT
;
SMIN    EQU    02H          ; Minimum cycle time
PMIN    EQU    01H          ; Minimum pulse width time
.
.
OSMS=#00000001B          ; Does not use divider circuit
SAIKURU=#SMIN             ; Sets initial cycle value
PARUSU=#PMIN             ; Sets initial pulse width value
CLR1    P3.0              ; Clears output latch to 0 if multiplexed pin is used
CLR1    PM3.0             ; Sets output mode if multiplexed pin is used
CALL    !SPG_INIT        ;
EI      ;
.
.
if(request for changing square wave)
    if(SAIKURU > PARUSU) (A) ; If SAIKURUP > PARUSU
        A=PARUSU            ; Data 1 → address XXX0
        A--                ; Data 2 → address XXX2
        A <<= 1            ; Data 3 → address XXX4
        X=A                ;
        A=#0               ; Table reference of low-order 8 bits of value stored to
        AX+=#PDAT          ; compare register
        HL=AX              ; X register ← low-order 8 bits
        X=[HL] (A)        ;
        HL++              ; Table reference of high-order 8 bits of value stored to compare register
        A=[HL]            ; A register ← high-order 8 bits
        PARUSUP=AX        ;
    ;
    A=SAIKURU             ; Cycle time storage processing
    A--                  ;
    A--                  ;
    A <<= 1              ;
    X=A                  ;
    A=#0                 ;
    AX+=#SDAT            ;
    HL=AX                ;
    X=[HL] (A)          ;
    HL++                 ;
    A=[HL]               ;
    SAIKURUP=AX         ;
    CLR1    TMIF00        ; Clears request flag
    CLR1    TMMK00        ; Enables compare register 00 interrupt
endif                    ; No data change
endif                    ;
.
.

```

## (3) SPD chart



## (4) Program list

```

PUBLIC SPG_INIT,PDAT,SDAT
PUBLIC SAIKURU,PARUSU
EXTRN SAIKURUP,PARUSUP
;
;*****
;
;          RAM definition
;*****
PPGRAM    DSEG    SADDR    ;
SAIKURU:   DS      1          ; 1 cycle time storage area
PARUSU:    DS      1          ; Pulse width storage area
;
;*****
;          PPG output initial setting
;*****
PPGINIT    CSEG
SPG_INIT:
    TMC0=#00000000B        ; Stops timer operation
    TCL0=#00100000B        ; Count clock of 16-bit timer register: 4.19 MHz
    CRC0=#00000000B        ; Uses CR00 and CR01 as compare register
    A=PARUSU                ; Data 1 → address XXX0
    A--                      ; Data 2 → address XXX2
    A <<= 1                 ; Data 3 → address XXX4
    X=A                      ;
    A=#0                    ; Table reference of low-order 8 bits of value stored to
    AX+=#PDAT                ; compare register
    HL=AX                    ; X register ← low-order 8 bits
    X=[HL] (A)              ;
    HL++                    ; Table reference of high-order 8 bits of value stored to compare register
    A=[HL]                  ; A register ← high-order 8 bits
    PARUSUP=AX              ;
;
;
;          A=SAIKURU        ; Cycle time storage processing
;          A--              ;
;          A--              ;
;          A <<= 1          ;
;          X=A              ;
;          A=#0            ;
;          AX+=#SDAT        ;
;          HL=AX            ;
;          X=[HL] (A)      ;
;          HL++            ;
;          A=[HL]          ;
;          SAIKURUP=AX     ;
;          CR00=SAIKURUP (AX) ; Sets compare register to 2 ms
;          CR01=PARUSUP (AX) ; Sets compare register to 1 ms
;          TOC0=#00011011B ; Sets successive pulse output and initial value 'H'
;          TMC0=#00001100B ; Starts on coincidence between TM0 and CR00 (enables timer operation)
;          RET              ;
;

```

```

PDAT:
    DW 4201          ; Address XXX0
    DW 8403          ; Address XXX2
    DW 12605         ; Address XXX4
    DW 16807
    DW 21009
    DW 25211
    DW 29413
    DW 33615
    DW 37817
SDAT:
    DW 8403          ; Address XXX0
    DW 12605         ; Address XXX2
    DW 16807         ; Address XXX4
    DW 21009
    DW 25211
    DW 29413
    DW 33615
    DW 37817
    DW 42019
    END

PUBLIC    PARUSUP, SAIKURUP
;
VETM00    CSEG    AT 20H
           DW      INTTM00
;
P2RAM     DSEG    SADDRP
PARUSUP:  DS      2          ; Pulse width time changing data storage area
SAIKURUP: DS      2          ; 1 cycle time changing data storage area
;*****
;    PPG output (cycle pulse width time changing interrupt)
;*****
TM00      CSEG
INTTM00:
    SEL    RB2          ; Selects bank 2
    CR01=PARUSUP (AX)  ; CR00, CR01 ← stores pulse width and cycle time changing data
    CR00=SAIKURUP (AX)
    SET1   TMMK00      ; Disables compare register 00 interrupt
    RETI
    END

```

## CHAPTER 6 APPLICATIONS OF 8-BIT TIMER/EVENT COUNTER

The 8-bit timer/event counter of the 78K/0 series has three functions: interval timer, external event counter, and square wave output. Two channels of 8-bit timers/event counters are provided and these timers/event counters can be used as a 16-bit timer/event counter when connected in cascade.

The 8-bit timers/event counters are set by the following registers:

- Timer clock select register 1 (TCL1)
- 8-bit timer mode control register (TMC1)
- 8-bit timer output control register (TOC1)
- Port mode register 3 (PM3)
- Port 3 (P3)

Figure 6-1. Format of Timer Clock Select Register 1

( $\mu$ PD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY subseries,  $\mu$ PD78070A, 78070AY)

|        |       |       |       |       |       |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TCL1   | TCL17 | TCL16 | TCL15 | TCL14 | TCL13 | TCL12 | TCL11 | TCL10 | FF41H   | 00H      | R/W |

| TCL13  | TCL12 | TCL11 | TCL10 | Selects count clock of 8-bit timer register 1 |                        |                        |
|--------|-------|-------|-------|---|------------------------|------------------------|
|        |       |       |       | MCS = 1                                       |                        | MCS = 0                |
| 0      | 0     | 0     | 0     | Falling edge of TI1                           |                        |                        |
| 0      | 0     | 0     | 1     | Rising edge of TI1                            |                        |                        |
| 0      | 1     | 1     | 0     | $f_{xx}/2$                                    | $f_x/2$ (2.5 MHz)      | $f_x/2^2$ (1.25 MHz)   |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$                                  | $f_x/2^2$ (1.25 MHz)   | $f_x/2^3$ (625 kHz)    |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$                                  | $f_x/2^3$ (625 kHz)    | $f_x/2^4$ (313 kHz)    |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$                                  | $f_x/2^4$ (313 kHz)    | $f_x/2^5$ (156 kHz)    |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$                                  | $f_x/2^5$ (156 kHz)    | $f_x/2^6$ (78.1 kHz)   |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$                                  | $f_x/2^6$ (78.1 kHz)   | $f_x/2^7$ (39.1 kHz)   |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$                                  | $f_x/2^7$ (39.1 kHz)   | $f_x/2^8$ (19.5 kHz)   |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$                                  | $f_x/2^8$ (19.5 kHz)   | $f_x/2^9$ (9.8 kHz)    |
| 1      | 1     | 1     | 0     | $f_{xx}/2^9$                                  | $f_x/2^9$ (9.8 kHz)    | $f_x/2^{10}$ (4.9 kHz) |
| 1      | 1     | 1     | 1     | $f_{xx}/2^{11}$                               | $f_x/2^{11}$ (2.4 kHz) | $f_x/2^{12}$ (1.2 kHz) |
| Others |       |       |       | Setting prohibited                            |                        |                        |

| TCL17  | TCL16 | TCL15 | TCL14 | Selects count clock of 8-bit timer register 2 |                        |                        |
|--------|-------|-------|-------|---|------------------------|------------------------|
|        |       |       |       | MCS = 1                                       |                        | MCS = 0                |
| 0      | 0     | 0     | 0     | Falling edge of TI2                           |                        |                        |
| 0      | 0     | 0     | 1     | Rising edge of TI2                            |                        |                        |
| 0      | 1     | 1     | 0     | $f_{xx}/2$                                    | $f_x/2$ (2.5 MHz)      | $f_x/2^2$ (1.25 MHz)   |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$                                  | $f_x/2^2$ (1.25 MHz)   | $f_x/2^3$ (625 kHz)    |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$                                  | $f_x/2^3$ (625 kHz)    | $f_x/2^4$ (313 kHz)    |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$                                  | $f_x/2^4$ (313 kHz)    | $f_x/2^5$ (156 kHz)    |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$                                  | $f_x/2^5$ (156 kHz)    | $f_x/2^6$ (78.1 kHz)   |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$                                  | $f_x/2^6$ (78.1 kHz)   | $f_x/2^7$ (39.1 kHz)   |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$                                  | $f_x/2^7$ (39.1 kHz)   | $f_x/2^8$ (19.5 kHz)   |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$                                  | $f_x/2^8$ (19.5 kHz)   | $f_x/2^9$ (9.8 kHz)    |
| 1      | 1     | 1     | 0     | $f_{xx}/2^9$                                  | $f_x/2^9$ (9.8 kHz)    | $f_x/2^{10}$ (4.9 kHz) |
| 1      | 1     | 1     | 1     | $f_{xx}/2^{11}$                               | $f_x/2^{11}$ (2.4 kHz) | $f_x/2^{12}$ (1.2 kHz) |
| Others |       |       |       | Setting prohibited                            |                        |                        |

**Caution** Before writing new data to TCL1, stop the timer operation once.

- Remarks**
1.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  2.  $f_x$  : main system clock oscillation frequency
  3. TI1 : input pin of 8-bit timer register 1
  4. TI2 : input pin of 8-bit timer register 2
  5. MCS: bit 0 of oscillation mode select register (OSMS)
  6. ( ) : at  $f_x = 5.0$  MHz

Figure 6-2. Format of Timer Clock Select Register 1 ( $\mu$ PD78098, 78098B subseries)

|        |       |       |       |       |       |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TCL1   | TCL17 | TCL16 | TCL15 | TCL14 | TCL13 | TCL12 | TCL11 | TCL10 | FF41H   | 00H      | R/W |

| TCL13  | TCL12 | TCL11 | TCL10 | Selects count clock of 8-bit timer register 1 |
|--------|-------|-------|-------|---|
| 0      | 0     | 0     | 0     | Falling edge of TI1                           |
| 0      | 0     | 0     | 1     | Rising edge of TI1                            |
| 0      | 1     | 1     | 0     | $f_{xx}/2$ (2.0 MHz)                          |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$ (1.0 MHz)                        |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$ (500 kHz)                        |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$ (250 kHz)                        |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$ (125 kHz)                        |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$ (62.5 kHz)                       |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$ (31.3 kHz)                       |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$ (15.6 kHz)                       |
| 1      | 1     | 1     | 0     | $f_{xx}/2^9$ (7.8 kHz)                        |
| 1      | 1     | 1     | 1     | $f_{xx}/2^{11}$ (2.0 kHz)                     |
| Others |       |       |       | Setting prohibited                            |

| TCL17  | TCL16 | TCL15 | TCL14 | Selects count clock of 8-bit timer register 2 |
|--------|-------|-------|-------|---|
| 0      | 0     | 0     | 0     | Falling edge of TI2                           |
| 0      | 0     | 0     | 1     | Rising edge of TI2                            |
| 0      | 1     | 1     | 0     | $f_{xx}/2$ (2.0 MHz)                          |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$ (1.0 MHz)                        |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$ (500 kHz)                        |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$ (250 kHz)                        |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$ (125 kHz)                        |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$ (62.5 kHz)                       |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$ (31.3 kHz)                       |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$ (15.6 kHz)                       |
| 1      | 1     | 1     | 0     | $f_{xx}/2^9$ (7.8 kHz)                        |
| 1      | 1     | 1     | 1     | $f_{xx}/2^{11}$ (2.0 kHz)                     |
| Others |       |       |       | Setting prohibited                            |

**Caution** Before writing new data to TCL1, stop the timer operation once.

- Remarks**
1.  $f_{xx}$  : main system clock frequency
  2. TI1: input pin of 8-bit timer register 1
  3. TI2: input pin of 8-bit timer register 2
  4. ( ): at  $f_{xx} = 4.0$  MHz



★

Figure 6-3. Format of Timer Clock Select Register 1 ( $\mu$ PD780018, 780018Y subseries)

|        |       |       |       |       |       |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TCL1   | TCL17 | TCL16 | TCL15 | TCL14 | TCL13 | TCL12 | TCL11 | TCL10 | FF41H   | 00H      | R/W |

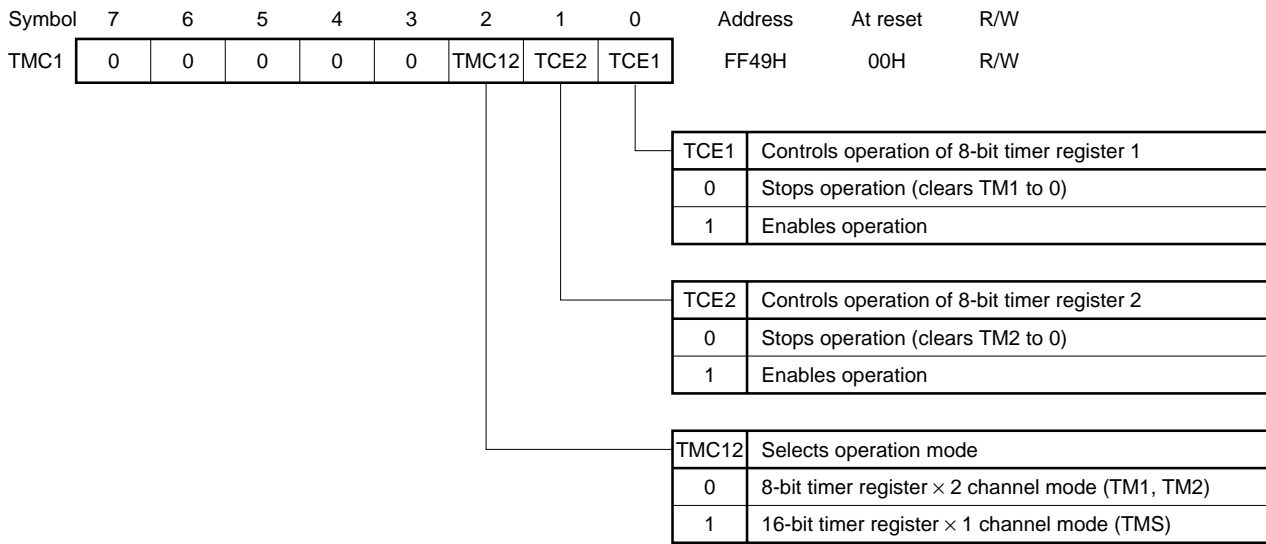
| TCL13  | TCL12 | TCL11 | TCL10 | Selects count clock of 8-bit timer register 1 |                        |
|--------|-------|-------|-------|---|------------------------|
| 0      | 0     | 0     | 0     | Falling edge of TI1                           |                        |
| 0      | 0     | 0     | 1     | Rising edge of TI1                            |                        |
| 0      | 1     | 1     | 0     | $f_{xx}/2$                                    | $f_x/2$ (2.5 MHz)      |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$                                  | $f_x/2^2$ (1.25 MHz)   |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$                                  | $f_x/2^3$ (625 kHz)    |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$                                  | $f_x/2^4$ (313 kHz)    |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$                                  | $f_x/2^5$ (156 kHz)    |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$                                  | $f_x/2^6$ (78.1 kHz)   |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$                                  | $f_x/2^7$ (39.1 kHz)   |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$                                  | $f_x/2^8$ (19.5 kHz)   |
| 1      | 1     | 1     | 0     | $f_{xx}/2^9$                                  | $f_x/2^9$ (9.8 kHz)    |
| 1      | 1     | 1     | 1     | $f_{xx}/2^{11}$                               | $f_x/2^{11}$ (2.4 kHz) |
| Others |       |       |       | Setting prohibited                            |                        |

| TCL17  | TCL16 | TCL15 | TCL14 | Selects count clock of 8-bit timer register 2 |                        |
|--------|-------|-------|-------|---|------------------------|
| 0      | 0     | 0     | 0     | Falling edge of TI2                           |                        |
| 0      | 0     | 0     | 1     | Rising edge of TI2                            |                        |
| 0      | 1     | 1     | 0     | $f_{xx}/2$                                    | $f_x/2$ (2.5 MHz)      |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$                                  | $f_x/2^2$ (1.25 MHz)   |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$                                  | $f_x/2^3$ (625 kHz)    |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$                                  | $f_x/2^4$ (313 kHz)    |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$                                  | $f_x/2^5$ (156 kHz)    |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$                                  | $f_x/2^6$ (78.1 kHz)   |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$                                  | $f_x/2^7$ (39.1 kHz)   |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$                                  | $f_x/2^8$ (19.5 kHz)   |
| 1      | 1     | 1     | 0     | $f_{xx}/2^9$                                  | $f_x/2^9$ (9.8 kHz)    |
| 1      | 1     | 1     | 1     | $f_{xx}/2^{11}$                               | $f_x/2^{11}$ (2.4 kHz) |
| Others |       |       |       | Setting prohibited                            |                        |

**Caution** Before writing new data to TCL1, stop the timer operation once.

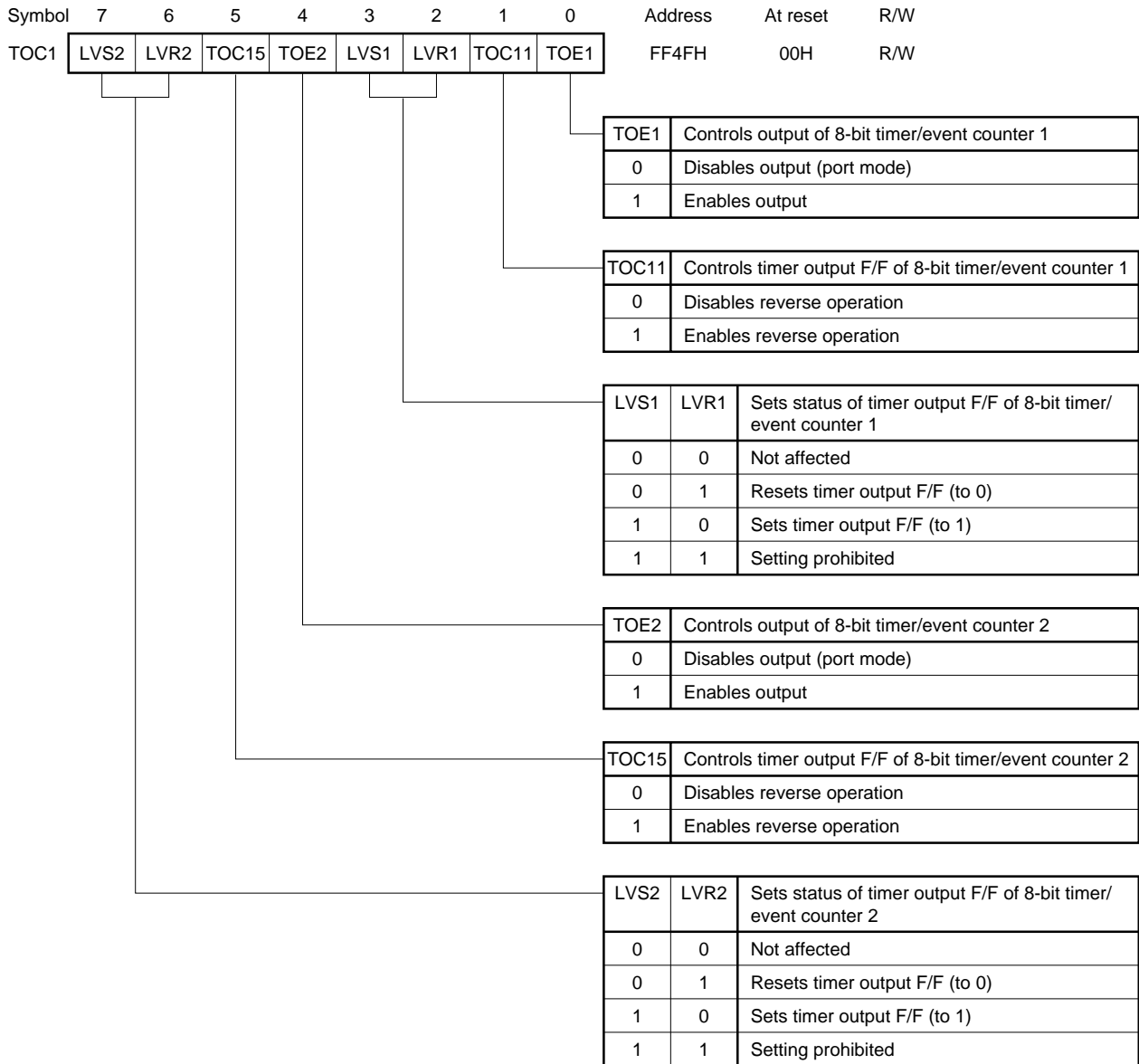
- Remarks**
1.  $f_{xx}$  : main system clock frequency ( $f_x$ )
  2.  $f_x$  : main system clock oscillation frequency
  3. TI1 : input pin of 8-bit timer register 1
  4. TI2 : input pin of 8-bit timer register 2
  5. ( ) : at  $f_x = 5.0$  MHz

Figure 6-4. Format of 8-Bit Timer Mode Control Register



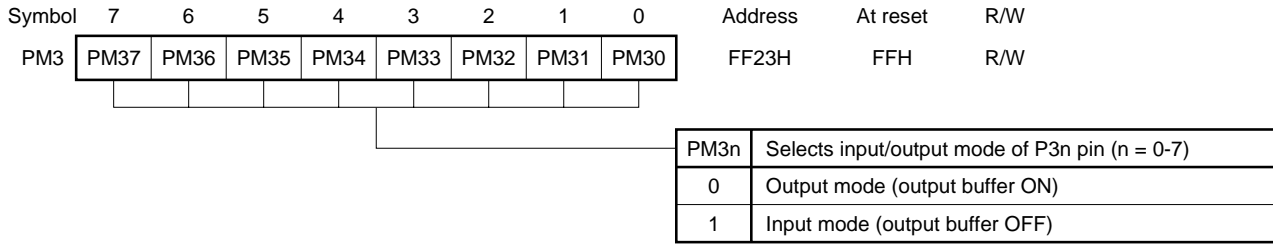
- Cautions**
1. Before changing the operation mode, stop the timer operation.
  2. When using the two 8-bit timer registers as a one 16-bit timer register, enable or stop the operation by using TCE1.

Figure 6-5. Format of 8-Bit Timer Output Control Register



- Cautions**
1. Before setting TOC1, be sure to stop the timer operation.
  2. LVS1, LVS2, LVR1, and LVR2 are always 0 when they are read.

Figure 6-6. Format of Port Mode Register 3



### 6.1 Setting of Interval Timer

When using an 8-bit timer/event counter as an interval timer, set an operation mode by the 8-bit timer mode control register (TMC1) and interval time by the timer clock select register 1 (TCL1).

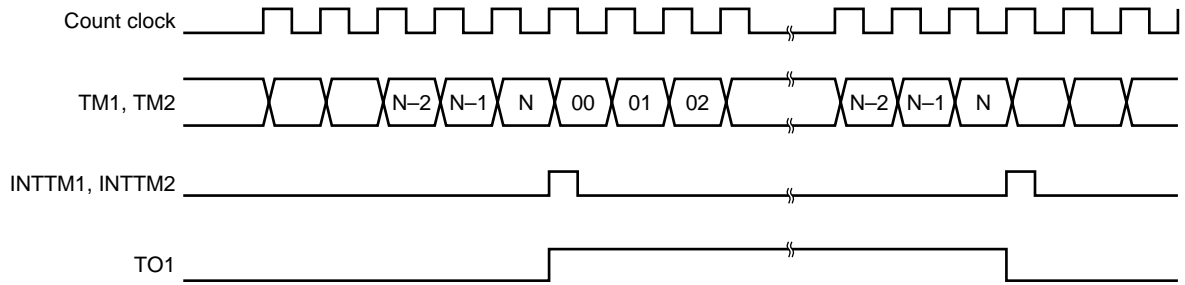
After that, set the values of the compare registers (CR10 and CR20) from the setup time and count clock. The setup time is determined by using the following expression:

$$\text{Setup time} = (\text{Compare register value} + 1) \times \text{Count clock cycle}$$

The setup time can be calculated in the same manner regardless of whether each 8-bit timer/event counter is used or two 8-bit timers/event counters are used as a 16-bit timer/event counter. The count clock when two 8-bit timers/event counters are used as a 16-bit timer/event counter, however, is selected by the bits 0 through 3 (TCL10 through TCL13) of TCL1.

Examples of the modes of the 8-bit timers and 16-bit timer are described next.

**Figure 6-7. Count timing of 8-Bit Timers**



**6.1.1 Setting of 8-bit timers**

In this example, 8-bit timer 2 is used to set two types of interval times: 500  $\mu\text{s}$  and 100 ms.

**(a) To set interval of 500  $\mu\text{s}$** 

<1> Setting of TMC1

Select the 8-bit timer register  $\times 2$  channel mode and enables the operation of the 8-bit timer 2.

<2> Setting of TCL1

Select  $f_{xx}/2^4$  that allows setting of 500  $\mu\text{s}$  or more and has the highest resolution (OSMS = 01H).

<3> Setting of CR20

$$500 \mu\text{s} = (N + 1) \times \frac{1}{4.19 \text{ MHz}/2^4}$$

$$N = 500 \mu\text{s} \times 4.19 \text{ MHz}/2^4 - 1 \doteq 130$$

**(1) Program list**

OSMS = #00000001B ; Does not use divider circuit

TCL1 = #10011001B ; Selects  $f_{xx}/2^4$  as count clock

CR20 = #130

TMC1 = #00000010B

**(b) To set interval of 100 ms**

<1> Setting of TMC1

Select the 8-bit timer register  $\times 2$  channel mode and enables the operation of the 8-bit timer 2.

<2> Setting of TCL1

Select  $f_{xx}/2^{11}$  that allows setting of 100 ms or more and has the highest resolution (OSMS = 01H).

<3> Setting of CR20

$$100 \text{ ms} = (N + 1) \times \frac{1}{4.19 \text{ MHz}/2^{11}}$$

$$N = 100 \text{ ms} \times 4.19 \text{ MHz}/2^{11} - 1 \doteq 204$$

**(1) Program list**

OSMS = #00000001B ; Does not use divider circuit

TCL1 = #11111111B ; Selects  $f_{xx}/2^{11}$  as count clock

CR20 = #204

TMC1 = #00000010B

**6.1.2 Setting of 16-bit timer**

In this example, 8-bit timers 1 and 2 are connected in cascade as a 16-bit timer to set two types of interval times: 500 ms and 10 s.

**(a) To set interval of 500 ms**

<1> Setting of TMC1

Select the 16-bit timer register × 1 channel mode and enables the operation of the 8-bit timers 1 and 2.

<2> Setting of TCL1

Select  $f_{xx}/2^5$  that allows setting of 500 ms or more and has the highest resolution (OSMS = 01H).

<3> Setting of CR10 and CR20

$$500 \text{ ms} = \frac{N + 1}{4.19 \text{ MHz}/2^5}$$

$$N = 500 \text{ ms} \times 4.19 \text{ MHz}/2^5 - 1 \doteq 65468 = \text{FF6CH}$$

$$\text{CR10} = 6\text{CH}, \text{CR20} = \text{FFH}$$

**(1) Program list**

OSMS = #00000001B ; Does not use divider circuit

TCL1 = #00001010B

CR10 = #06CH ; Sets 65468 to CR10 and CR20

CR20 = #0FFH ; CR10 = 6CH, CR20 = FFH

TMC1 = #00000111B

**(b) To set interval of 10 s**

<1> Setting of TMC1

Select the 16-bit timer register × 1 channel mode and enable the operation of the 8-bit timers 1 and 2.

<2> Setting of TCL1

Select  $f_{xx}/2^{11}$  that allows setting of 10 s or more and has the highest resolution (OSMS = 01H).

<3> Setting of CR10 and CR20

$$10 \text{ s} = \frac{N + 1}{4.19 \text{ MHz}/2^{11}}$$

$$N = 10 \text{ s} \times 4.19 \text{ MHz}/2^{11} - 1 \doteq 20458 = 4\text{FEAH}$$

$$\text{CR10} = \text{EAH}, \text{CR20} = 4\text{FH}$$

**(1) Program list**

OSMS = #00000001B ; Does not use divider circuit

TCL1 = #00001111B

CR10 = #0EAH ; Sets 20458 to CR10 and CR20

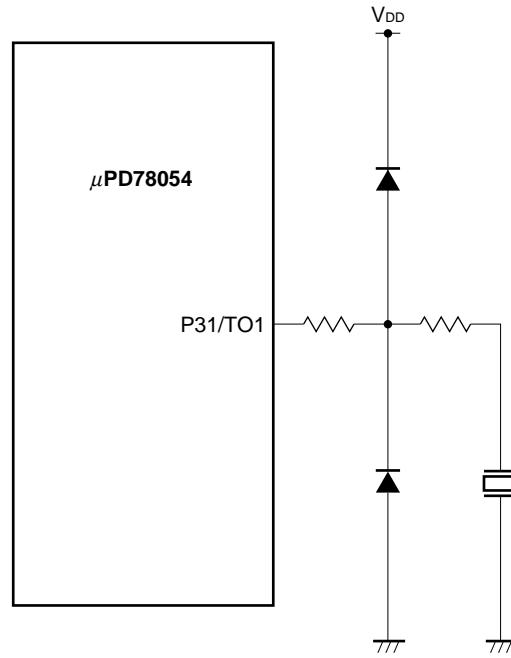
CR20 = #4FH ; CR10 = EAH, CR20 = 4FH

TMC1 = #00000111B

## 6.2 Musical Scale Generation

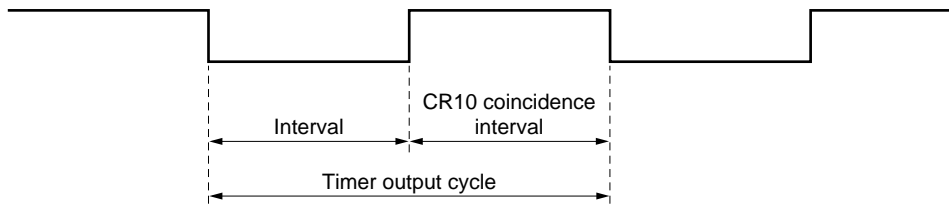
This section shows an example of a program that uses the square wave output (P31/TO1) of an 8-bit timer/event counter and generates a musical scale by supplying pulses to an external buzzer.

**Figure 6-8. Musical Scale Generation Circuit**



The output frequency of the P31/TO1 pin is set by the count clock and a compare register. In this example, the central frequency of the musical scale is set to a range of 523 to 1046 Hz. Therefore,  $f_{xx}/2^5$  is selected as the count clock (oscillation mode select register: OSMS = 01H). Table 6-1 shows the musical scale, the set value of the compare register, and frequency of the output pulse. Because one cycle of the timer output is created when the value of the timer coincides with the value of the compare register two times, the interval time is set as half a cycle time.

**Figure 6-9. Timer Output and Interval**





As for the time length of a sound, the output time is determined by setting an interval time with 8-bit timer/event counter 2 and by counting the number of times the interrupt generated by the timer/event counter. In this example, 8-bit timer/event counter 2 is set to 20 ms.

**Table 6-1. Musical Scale and Frequency**

| Musical Scale | Musical Scale Frequency Hz | Compare Register Value | Output Frequency Hz |
|---------------|----------------------------|------------------------|---------------------|
| Do            | 523.25                     | 124                    | 524.3               |
| Re            | 587.33                     | 111                    | 585.1               |
| Mi            | 659.25                     | 98                     | 662.0               |
| Fa            | 698.46                     | 93                     | 697.2               |
| So            | 783.98                     | 83                     | 780.2               |
| La            | 880.00                     | 73                     | 885.6               |
| Tee           | 987.77                     | 65                     | 993.0               |
| Do            | 1046.5                     | 62                     | 1040                |

The format of the data table for this program is shown below.

TABLE:

```

DB musical scale data 1, sound length data 1
DB musical scale data 2, sound length data 2
  :
  :
DB musical scale data n, sound length data n
DB 0, 0
    
```

The musical scale data is set to 0 for rest, and the sound length data is set to 0 for the end of data.

**Example** Number of counts of 8-bit timer/event counter to output sound for 1 second  
 Number of counts =  $1 \text{ s} / 20 \text{ ms} = 50$  (50 is set as number of counts)

This program sequentially outputs do, re, mi, and so on, for 1 second each.

**(1) Description of package****<Public declaration symbol>**

MLDY: Subroutine name of musical scale generation program

**<Registers used>**

Bank 0: A, B, HL

**<RAM used>**

| Name  | Usage                              | Attribute | Bytes |
|-------|------------------------------------|-----------|-------|
| POINT | Stores pointer value of table data | SADDR     | 1     |
| LNG   | Counts sound length data           |           |       |

**<Nesting>**

1 level 3 bytes

**<Hardware used>**

- 8-bit timer/event counters 1 and 2
- P31/TO1

**<Initial setting>**

- Sets by subroutine MLDY
- Enables interrupt

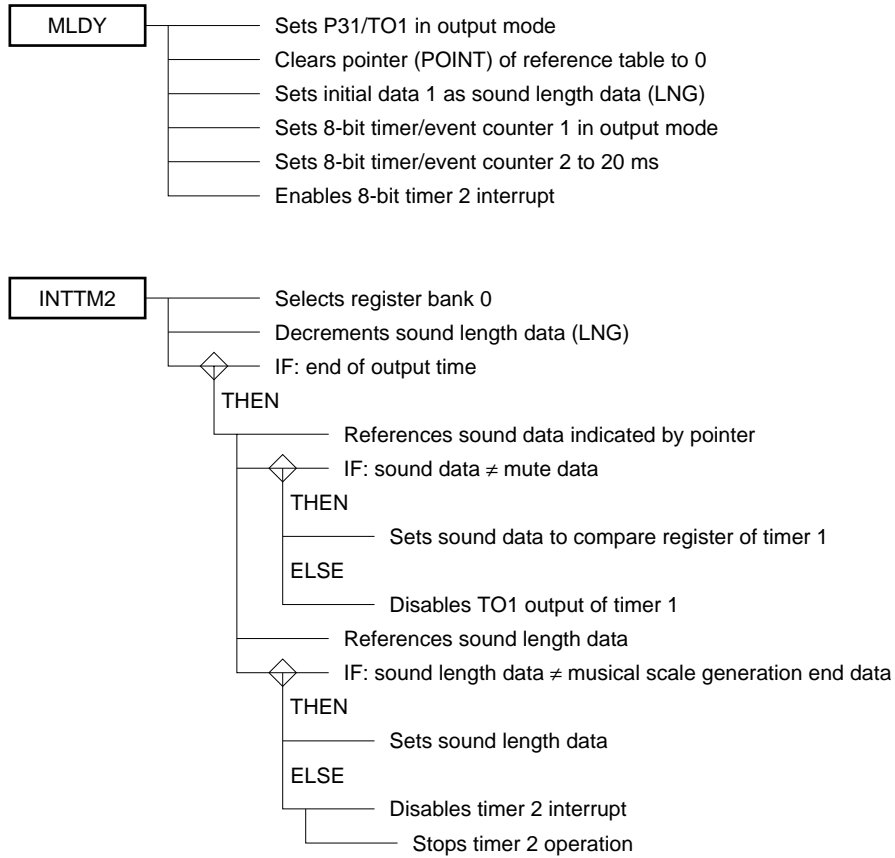
**<Starting>**

- Call subroutine MLDY

**(2) Example of use**

```
EXTRN MLDY
:
CALL !MLDY
EI
```

(3) SPD chart



## (4) Program list

```

PUBLIC MLDY

VETM2  CSEG  AT 26H
        DW    INTTM2                ; Sets vector address of 8-bit timer/event counter

ML_DAT  DSEG  SADDR
POINT:  DS    1                    ; Pointer for table data
LNG:    DS    1                    ; Sound length data

;*****
;*      Musical scale generation initialize
;*****
ML_SEG  CSEG
MLDY:
        CLR   PM3.1                ; Sets P3.1 in output mode
        POINT=#0                  ; Initial setting of pointer
        LGN=#1
        OSMS=#0000001B            ; Does not use divider circuit
        TOC1=#00000011B          ; Sets TO1 output mode
        TCL1=#11101010B
        CR20=#163                 ; Sets timer 2 to 20 ms
        TMC1=#00000010B          ; Enables timer 2 operation
        CLR1  TMMK2               ; Enables timer 2 interrupt
        RET

$EJECT

```

```

;*****
;      Sets musical scale generation data
;*****
TM2_SEG CSEG
INTTM2:
    SEL RBO
    LNG--
    if(LNG==#0)
        B=POINT (A)
        HL=#TABLE                ; Sets table first address
        A=[HL+B]
        if(A!="#0)
            CLR1   TCE1          ; Sets sound data
            CR10=A
            SET1   TOE1
            SET1   TCE1
        else
            CLR1   TOE1
        endif

        B++                    ; Increments pointer
        A=[HL+B]                ; Loads sound length data
        if(A!="#0)              ; Sound output in progress?
            LNG=A                ; Sets sound length data
            B++
            POINT=B (A)
        else
            SET1   TMMK2         ; Disables timer 2 interrupt
            CLR1   TCE2         ; Stops timer 2 operation
        endif
    endif
    RETI
;*****
;      Musical scale data table
;*****
TABLE:
    DB 124,50                    ; Do
    DB 111,50                    ; Re
    DB 98,50                     ; Mi
    DB 93,50                     ; Fa
    DB 83,50                     ; So
    DB 73,50                     ; La
    DB 65,50                     ; Tee
    DB 62,50                     ; Do
    DB 00,00                     ; End

```

[MEMO]

## CHAPTER 7 APPLICATIONS OF WATCH TIMER

The watch timer of the 78K/0 series has a watch timer function that causes the timer to overflow every 0.5 second by using the main system clock or subsystem clock as the clock source, and an interval timer function that allows you to set six types of reference times. These two functions can be simultaneously used.

The watch timer is set by using timer clock select register 2 (TCL2) and watch timer mode control register (TMC2).

**Figure 7-1. Format of Timer Clock Select Register 2**

( $\mu$ PD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY subseries,  $\mu$ PD78070A, 78070AY)

|        |       |       |       |       |   |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|---|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3 | 2     | 1     | 0     | Address | At reset | R/W |
| TCL2   | TCL27 | TCL26 | TCL25 | TCL24 | 0 | TCL22 | TCL21 | TCL20 | FF42H   | 00H      | R/W |

| TCL22 | TCL21 | TCL20 | Selects count clock of watchdog timer |                        |                        |
|-------|-------|-------|---------------------------------------|------------------------|------------------------|
|       |       |       |                                       | MCS = 1                | MCS = 0                |
| 0     | 0     | 0     | $f_{xx}/2^3$                          | $f_x/2^3$ (625 kHz)    | $f_x/2^4$ (313 kHz)    |
| 0     | 0     | 1     | $f_{xx}/2^4$                          | $f_x/2^4$ (313 kHz)    | $f_x/2^5$ (156 kHz)    |
| 0     | 1     | 0     | $f_{xx}/2^5$                          | $f_x/2^5$ (156 kHz)    | $f_x/2^6$ (78.1 kHz)   |
| 0     | 1     | 1     | $f_{xx}/2^6$                          | $f_x/2^6$ (78.1 kHz)   | $f_x/2^7$ (39.1 kHz)   |
| 1     | 0     | 0     | $f_{xx}/2^7$                          | $f_x/2^7$ (39.1 kHz)   | $f_x/2^8$ (19.5 kHz)   |
| 1     | 0     | 1     | $f_{xx}/2^8$                          | $f_x/2^8$ (19.5 kHz)   | $f_x/2^9$ (9.8 kHz)    |
| 1     | 1     | 0     | $f_{xx}/2^9$                          | $f_x/2^9$ (9.8 kHz)    | $f_x/2^{10}$ (4.9 kHz) |
| 1     | 1     | 1     | $f_{xx}/2^{11}$                       | $f_x/2^{11}$ (2.4 kHz) | $f_x/2^{12}$ (1.2 kHz) |

| TCL24 | Selects count clock of watch timer |                      |                      |
|-------|------------------------------------|----------------------|----------------------|
|       |                                    | MCS = 1              | MCS = 0              |
| 0     | $f_{xx}/2^7$                       | $f_x/2^7$ (39.1 kHz) | $f_x/2^8$ (19.5 kHz) |
| 1     | $f_{XT}$ (32.768 kHz)              |                      |                      |

| TCL27 | TCL26 | TCL25 | Selects frequency of buzzer output |                        |                        |
|-------|-------|-------|------------------------------------|------------------------|------------------------|
|       |       |       |                                    | MCS = 1                | MCS = 0                |
| 0     | ×     | ×     | Disables buzzer output             |                        |                        |
| 1     | 0     | 0     | $f_{xx}/2^9$                       | $f_x/2^9$ (9.8 kHz)    | $f_x/2^{10}$ (4.9 kHz) |
| 1     | 0     | 1     | $f_{xx}/2^{10}$                    | $f_x/2^{10}$ (4.9 kHz) | $f_x/2^{11}$ (2.4 kHz) |
| 1     | 1     | 0     | $f_{xx}/2^{11}$                    | $f_x/2^{11}$ (2.4 kHz) | $f_x/2^{12}$ (1.2 kHz) |
| 1     | 1     | 1     | Setting prohibited                 |                        |                        |

**Caution** Before writing new data to TCL2, stop the timer operation once.

- Remarks**
1.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  2.  $f_x$  : main system clock oscillation frequency
  3.  $f_{XT}$  : subsystem clock oscillation frequency
  4. × : don't care
  5. MCS: bit 0 of oscillation mode select register (OSMS)
  6. ( ) : at  $f_x = 5.0$  MHz or  $f_{XT} = 32.768$  kHz



Figure 7-2. Format of Timer Clock Select Register 2 ( $\mu$ PD78098, 78098B subseries)

|        |       |       |       |       |   |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|---|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3 | 2     | 1     | 0     | Address | At reset | R/W |
| TCL2   | TCL27 | TCL26 | TCL25 | TCL24 | 0 | TCL22 | TCL21 | TCL20 | FF42H   | 00H      | R/W |

| TCL22 | TCL21 | TCL20 | Selects count clock of watchdog timer |
|-------|-------|-------|---------------------------------------|
| 0     | 0     | 0     | $f_{xx}/2^3$ (500 kHz)                |
| 0     | 0     | 1     | $f_{xx}/2^4$ (250 kHz)                |
| 0     | 1     | 0     | $f_{xx}/2^5$ (125 kHz)                |
| 0     | 1     | 1     | $f_{xx}/2^6$ (62.5 kHz)               |
| 1     | 0     | 0     | $f_{xx}/2^7$ (31.3 kHz)               |
| 1     | 0     | 1     | $f_{xx}/2^8$ (15.6 kHz)               |
| 1     | 1     | 0     | $f_{xx}/2^9$ (7.8 kHz)                |
| 1     | 1     | 1     | $f_{xx}/2^{11}$ (2.0 kHz)             |

| TCL24 | Selects count clock of watch timer |
|-------|------------------------------------|
| 0     | $f_{xx}/2^7$ (31.3 kHz)            |
| 1     | $f_{XT}$ (32.768 kHz)              |

| TCL27 | TCL26 | TCL25 | Selects frequency of buzzer output |
|-------|-------|-------|------------------------------------|
| 0     | ×     | ×     | Disables buzzer output             |
| 1     | 0     | 0     | $f_{xx}/2^9$ (7.8 kHz)             |
| 1     | 0     | 1     | $f_{xx}/2^{10}$ (3.9 kHz)          |
| 1     | 1     | 0     | $f_{xx}/2^{11}$ (1.95 kHz)         |
| 1     | 1     | 1     | Setting prohibited                 |

**Caution** Before writing new data to TCL2, stop the timer operation once.

- Remarks**
1.  $f_{xx}$ : main system clock frequency
  2.  $f_{XT}$ : subsystem clock oscillation frequency
  3. × : don't care
  4. ( ): at  $f_{xx} = 4.0$  MHz or  $f_{XT} = 32.768$  kHz

★ **Figure 7-3. Format of Timer Clock Select Register 2 ( $\mu$ PD780018, 780018Y subseries)**

|        |       |       |       |       |   |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|---|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3 | 2     | 1     | 0     | Address | At reset | R/W |
| TCL2   | TCL27 | TCL26 | TCL25 | TCL24 | 0 | TCL22 | TCL21 | TCL20 | FF42H   | 00H      | R/W |

|       |       |       |                                       |  |                        |  |
|-------|-------|-------|---------------------------------------|--|------------------------|--|
| TCL22 | TCL21 | TCL20 | Selects count clock of watchdog timer |  |                        |  |
| 0     | 0     | 0     | $f_{xx}/2^3$                          |  | $f_x/2^3$ (625 kHz)    |  |
| 0     | 0     | 1     | $f_{xx}/2^4$                          |  | $f_x/2^4$ (313 kHz)    |  |
| 0     | 1     | 0     | $f_{xx}/2^5$                          |  | $f_x/2^5$ (156 kHz)    |  |
| 0     | 1     | 1     | $f_{xx}/2^6$                          |  | $f_x/2^6$ (78.1 kHz)   |  |
| 1     | 0     | 0     | $f_{xx}/2^7$                          |  | $f_x/2^7$ (39.1 kHz)   |  |
| 1     | 0     | 1     | $f_{xx}/2^8$                          |  | $f_x/2^8$ (19.5 kHz)   |  |
| 1     | 1     | 0     | $f_{xx}/2^9$                          |  | $f_x/2^9$ (9.8 kHz)    |  |
| 1     | 1     | 1     | $f_{xx}/2^{11}$                       |  | $f_x/2^{11}$ (2.4 kHz) |  |

|       |                                    |  |                      |  |
|-------|------------------------------------|--|----------------------|--|
| TCL24 | Selects count clock of watch timer |  |                      |  |
| 0     | $f_{xx}/2^7$                       |  | $f_x/2^7$ (39.1 kHz) |  |
| 1     | $f_{XT}$                           |  |                      |  |

|       |       |       |                                    |  |                        |
|-------|-------|-------|------------------------------------|--|------------------------|
| TCL27 | TCL26 | TCL25 | Selects frequency of buzzer output |  |                        |
| 0     | ×     | ×     | Disables buzzer output             |  |                        |
| 1     | 0     | 0     | $f_{xx}/2^9$                       |  | $f_x/2^9$ (9.8 kHz)    |
| 1     | 0     | 1     | $f_{xx}/2^{10}$                    |  | $f_x/2^{10}$ (4.9 kHz) |
| 1     | 1     | 0     | $f_{xx}/2^{11}$                    |  | $f_x/2^{11}$ (2.4 kHz) |
| 1     | 1     | 1     | Setting prohibited                 |  |                        |

**Caution** Before writing new data to TCL2, stop the timer operation once.

- Remarks**
1.  $f_{xx}$ : main system clock frequency ( $f_x$ )
  2.  $f_x$  : main system clock oscillation frequency
  3.  $f_{XT}$ : subsystem clock oscillation frequency
  4. × : don't care
  5. ( ): at  $f_x = 5.0$  MHz or  $f_{XT} = 32.768$  kHz

**Figure 7-4. Format of Watch Timer Mode Control Register**

( $\mu$ PD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 780018, 780018Y, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY subseries,  $\mu$ PD78070A, 78070AY)

|        |   |       |       |       |       |       |       |       |         |          |     |
|--------|---|-------|-------|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7 | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TMC2   | 0 | TMC26 | TMC25 | TMC24 | TMC23 | TMC22 | TMC21 | TMC20 | FF4AH   | 00H      | R/W |

|       |  |  |  |
|-------|--|--|--|
| TMC20 | Selects watch operation mode                       |  |  |
| 0     | Normal operation mode (sets flag at $f_w/2^{14}$ ) |  |  |
| 1     | Fast-forward mode (sets flag at $f_w/2^5$ )        |  |  |

|       |                                 |  |  |
|-------|---------------------------------|--|--|
| TMC21 | Controls operation of prescaler |  |  |
| 0     | Clears after operation stopped  |  |  |
| 1     | Enables operation               |  |  |

|       |                                     |  |  |
|-------|-------------------------------------|--|--|
| TMC22 | Controls operation of 5-bit counter |  |  |
| 0     | Clears after operation stopped      |  |  |
| 1     | Enables operation                   |  |  |

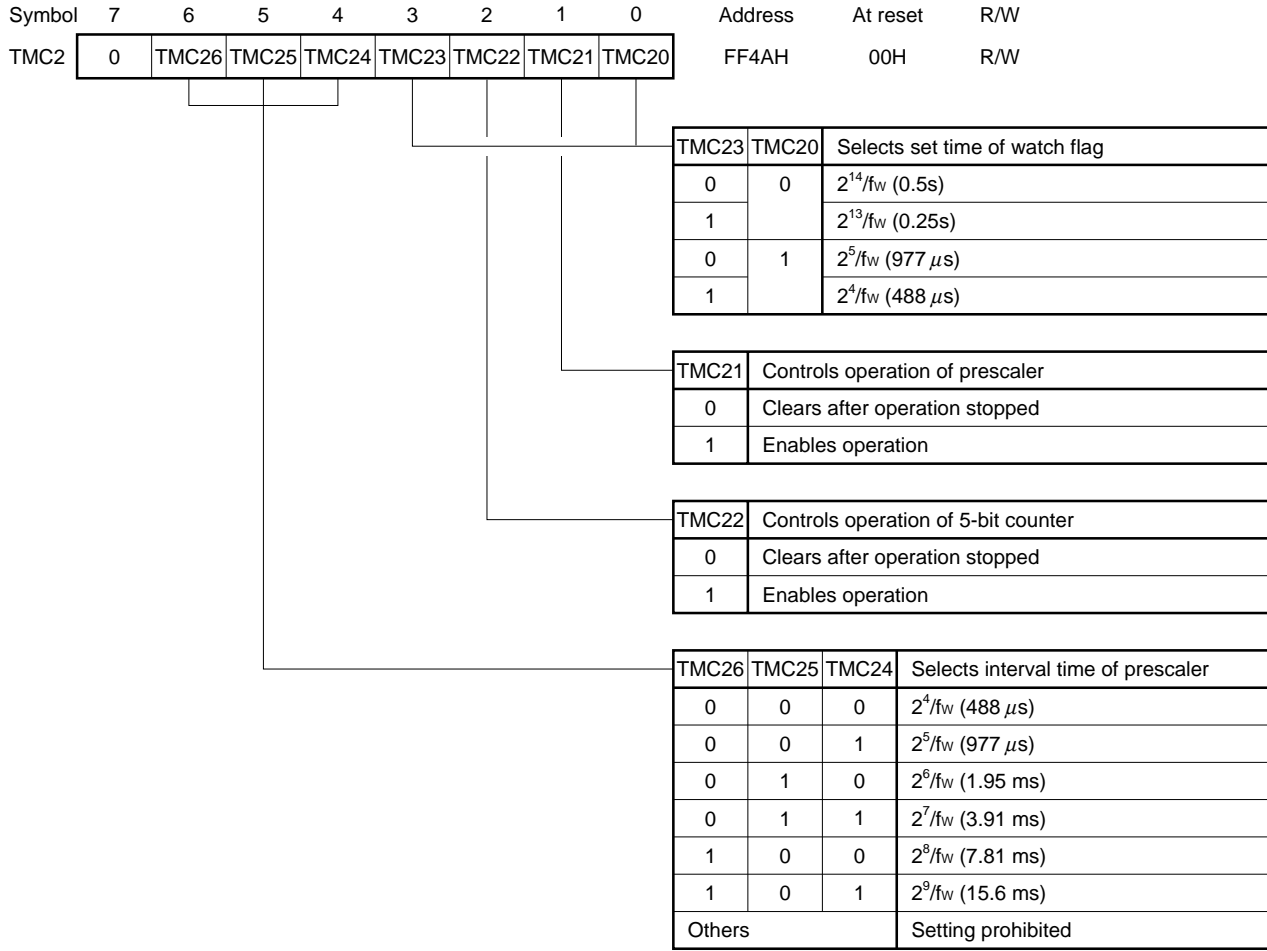
|       |                                 |                         |                          |
|-------|---------------------------------|-------------------------|--------------------------|
| TMC23 | Selects set time of watch timer |                         |                          |
|       | At $f_{xx} = 5.0$ MHz           | At $f_{xx} = 4.19$ MHz  | At $f_{XT} = 32.768$ kHz |
| 0     | $2^{14}/f_w$ (0.4 sec)          | $2^{14}/f_w$ (0.5 sec)  | $2^{14}/f_w$ (0.5 sec)   |
| 1     | $2^{13}/f_w$ (0.2 sec)          | $2^{13}/f_w$ (0.25 sec) | $2^{13}/f_w$ (0.25 sec)  |

|        |       |       |                                    |                         |                          |
|--------|-------|-------|------------------------------------|-------------------------|--------------------------|
| TMC26  | TMC25 | TMC24 | Selects interval time of prescaler |                         |                          |
|        |       |       | At $f_{xx} = 5.0$ MHz              | At $f_{xx} = 4.19$ MHz  | At $f_{XT} = 32.768$ kHz |
| 0      | 0     | 0     | $2^4/f_w$ (410 $\mu$ s)            | $2^4/f_w$ (488 $\mu$ s) | $2^4/f_w$ (488 $\mu$ s)  |
| 0      | 0     | 1     | $2^5/f_w$ (819 $\mu$ s)            | $2^5/f_w$ (977 $\mu$ s) | $2^5/f_w$ (977 $\mu$ s)  |
| 0      | 1     | 0     | $2^6/f_w$ (1.64 ms)                | $2^6/f_w$ (1.95 ms)     | $2^6/f_w$ (1.95 ms)      |
| 0      | 1     | 1     | $2^7/f_w$ (3.28 ms)                | $2^7/f_w$ (3.91 ms)     | $2^7/f_w$ (3.91 ms)      |
| 1      | 0     | 0     | $2^8/f_w$ (6.55 ms)                | $2^8/f_w$ (7.81 ms)     | $2^8/f_w$ (7.81 ms)      |
| 1      | 0     | 1     | $2^9/f_w$ (13.1 ms)                | $2^9/f_w$ (15.6 ms)     | $2^9/f_w$ (15.6 ms)      |
| Others |       |       | Setting prohibited                 |                         |                          |

**Caution** Do not often clear the prescaler when the watch timer is used.

- Remarks**
1.  $f_w$  : watch timer clock frequency ( $f_{xx}/2^7$  or  $f_{XT}$ )
  2.  $f_{xx}$ : main system clock frequency ( $f_x$  or  $f_x/2$ )
  3.  $f_x$  : main system clock oscillation frequency
  4.  $f_{XT}$ : subsystem clock oscillation frequency

Figure 7-5. Format of Watch Timer Mode Control Register ( $\mu$ PD78098, 78098B subseries)



**Caution** Do not often clear the prescaler when the watch timer is used.

- Remarks**
1.  $f_w$  : watch timer clock frequency ( $f_x/2^8$  or  $f_{XT}$ )
  2. ( ): at  $f_w = 32.768$  kHz

## 7.1 Watch and LED Display Program

As an example of using the watch timer, this section introduces a program that counts time by using an 0.5 second overflow and dynamically displays LED at intervals of 1.95 ms.

To count time, an overflow flag is tested each time a subroutine is called. When the flag is set, time is counted up in seconds. Because an overflow occurs every 0.5 second, it takes 1 minute to count 120 times. The overflow flag is tested at intervals of 1.95 ms so that the flag is tested without fail. The watch of this program is 24-hour watch. The high-order and low-order digits of minute and hour data are stored in separate areas of memory.

**Figure 7-6. Concept of Watch Data**

| Second data | Minute data            |                         | Hour data              |                         |
|-------------|------------------------|-------------------------|------------------------|-------------------------|
| 0-120       | Low-order<br>digit 0-9 | High-order<br>digit 0-5 | Low-order<br>digit 0-9 | High-order<br>digit 0-2 |

As LED dynamic display, four digits are displayed with the display digit changed at intervals of 1.95 ms. In this example, the high-order 4 bits of P3 are used as a digit signal, and P5 that can directly drive an LED is selected as a segment signal.

The digit of an LED specified by a display digit area (DIGCT) in an LED display area is displayed. To change the digit signal, the segment signal is turned off so that the adjacent digits are not displayed.

Figure 7-7. LED Display Timing

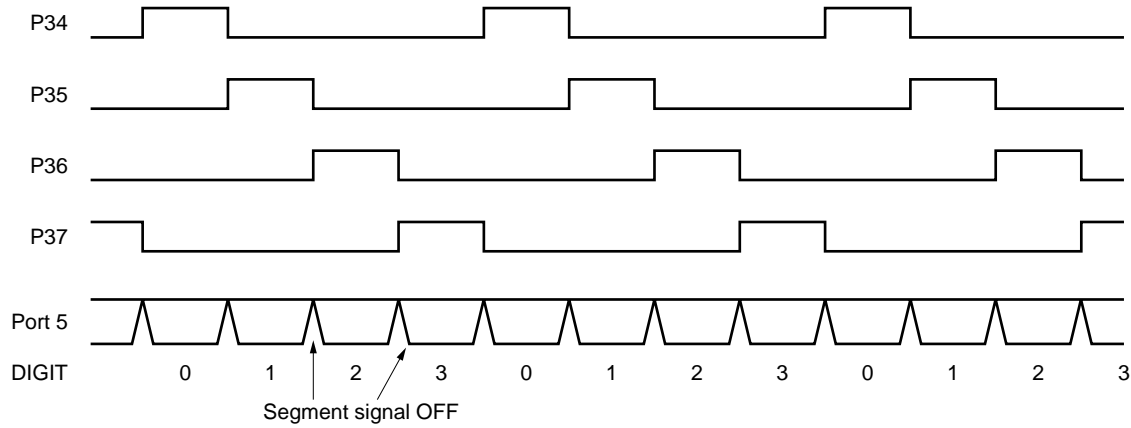
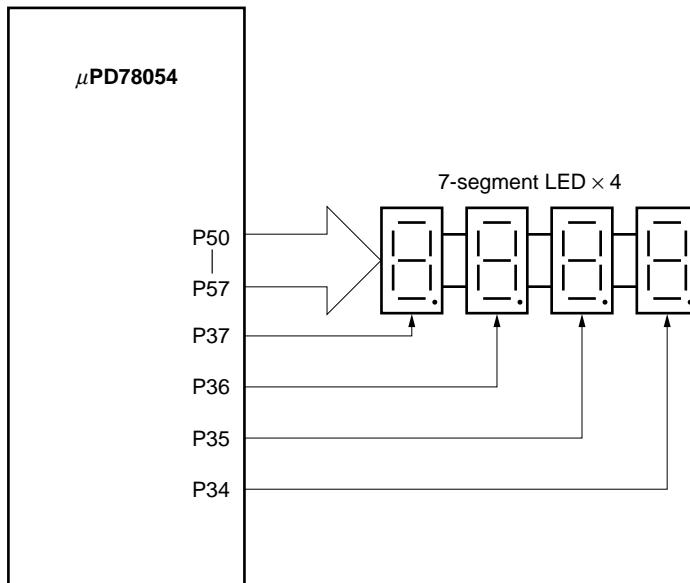


Figure 7-8. Circuit Example of Watch Timer



**(1) Description of package****<Public declaration symbol>**

SECD : second data storage area  
 MINDP : minute data storage area  
 HOURDP : hour data storage area  
 LEDDP : LED display area

**<Register used>**

Bank 0: AX, B, HL

**<RAM used>**

| Name   | Usage                         | Attribute | Bytes |
|--------|-------------------------------|-----------|-------|
| MINDP  | Stores minute data            | SADDRP    | 2     |
| HOURDP | Stores hour data              |           |       |
| SECD   | Stores second data            |           | 1     |
| DIGCT  | Stores LED display digit data |           | 4     |
| LEDDP  | LED display data              |           |       |

**<Hardware used>**

- Watch timer
- P34-37
- P5

**<Initial setting>**

- TMC2 = #00100110B ; 0.5-second watch operation at 1.95 ms interval
- TMMK3 = 0 ; enables watch timer interrupt

**<Starting>**

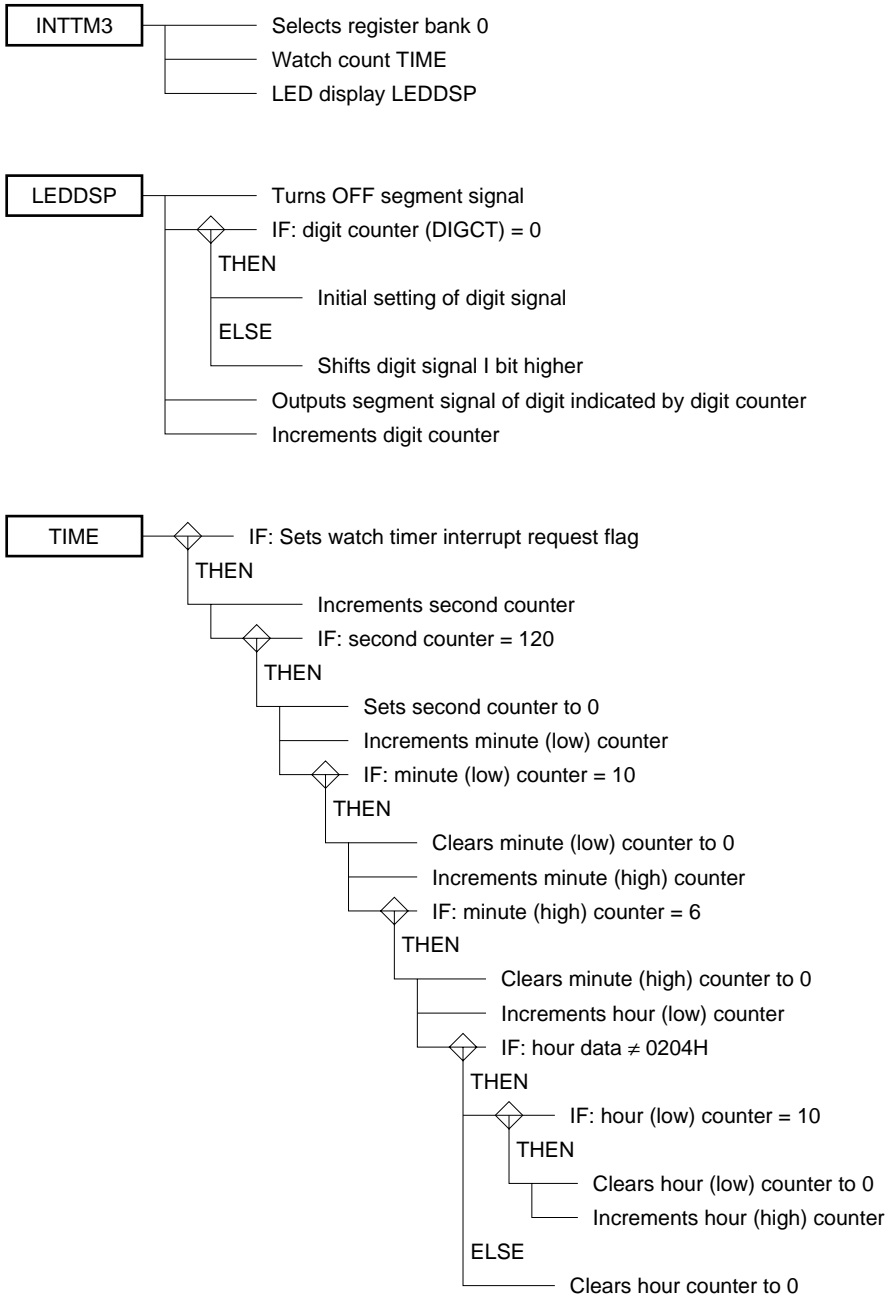
Started by the interval timer interrupt request of the watch timer.

**(2) Example of use**

```
EXTRN MINDP, HOURDP, SECD, LEDDP
```

```
TMC2 = #00100110B ; 0.5-second watch operation at 1.95 ms interval
CLR1 TMMK3 ; Enables watch timer interrupt
EI
```

(3) SPD chart





**(4) Program list**

```
        PUBLIC  HOURDP,MINDP,SECD,LEDDP

WT_DATP DSEG  SADDRP
MINDP: DS    2                ; Minute data storage area
HOURDP: DS    2                ; Hour data storage area
SECD:  DS    1                ; Second data storage area
DIGCT: DS    1                ; LED display digit area
LEDDP: DS    4                ; LED display area

VETM3  CSEG   AT 1EH
        DW    INTTM3          ; Sets vector address of watch timer

;*****
;*   Interval interrupt processing
;*****
TM3_SEG CSEG
INTTM3:
        SEL  RB0
        CALL !TIME
        CALL !LEDDPSP
        RETI
```

```

;*****
;          LED display
;*****
LEDDPSP:
    P5=#0FFH                ; Turns OFF segment output
    DIGCT&=#00000011B      ; Adjusts digit counter (0-3)
    if (DIGCT==#0)
        A=P3
        A&=#00001111B      ; Initial setting of digit signal (high-order 4 bits)
        A|=#00010000B
        P3=A
    else
        A=P3
        A&=#11110000B      ; Shifts high-order 4 bits
        X=A
        A=P3
        A+=X
        P3=A
    endif

    B=DIGCT (A)             ; Sets address of display data
    HL=#LEDDP              ; Display area first address
    B=[HL+B] (A)           ; Sets display data
    HL=#SEGDT              ; Conversion to segment data
    P5=[HL+B] (A)         ; Outputs segment signal

    DIGCT++
    RET
SEGDT:
    DB 11000000B           ; 0
    DB 11111001B           ; 1
    DB 10100100B           ; 2
    DB 10110000B           ; 3
    DB 10011001B           ; 4
    DB 10010010B           ; 5
    DB 10000010B           ; 6
    DB 11111000B           ; 7
    DB 10000000B           ; 8
    DB 10010000B           ; 9
    DB 10001000B           ; A
    DB 10000011B           ; B
    DB 11000110B           ; C
    DB 10100001B           ; D
    DB 10000110B           ; E
    DB 10001110B           ; F
$EJECT

```

```

;*****
;*      Watch count up
;*****
TIME:                                     ; 0.5 second test
    if_bit(WTIF)
        CLR1      WTIF                    ; 120 = 60 seconds/0.5
        SECD++
        if(SECD==#120)
            SECD=#0                        ; Increments minute (low)
            (MINDP+0)++                    ; Carry occurs
            if((MINDP+0)==#10)
                (MINDP+0)=#0              ; Increments minute (high)
                (MINDP+1)++              ; Carry occurs
                if(MINDP+1==#6)
                    (MINDP+1)=#0
                    (HOURDP+0)++         ; Hour data 24?
                    if(HOURDP!=#0204H) (AX) ; Carry occurs
                        if((HOURDP+0)==#10)
                            (HOURDP+0)=#0
                            (HOURDP+1)++
                        endif
                    else
                        HOURDP=#0000H
                    endif
                endif
            endif
        endif
    endif
endif
RET

```

[MEMO]

## CHAPTER 8 APPLICATIONS OF SERIAL INTERFACE

The 78K/0 series is provided with the serial interface shown in Table 8-1.

★

**Table 8-1. Serial Interface Channel of Each Subseries**

| Configuration of Serial Interface<br><br>Subseries | Channel 0 |        |     |                      | Channel 1 |   | Channel 2 |        | Channel 3 | Channel 4                          | Channel 5                                      |
|--|-----------|--------|-----|----------------------|-----------|---|-----------|--------|-----------|------------------------------------|--|
|  | 3-wire    | 2-wire | SBI | I <sup>2</sup> C bus | 3-wire    | 3-wire with automatic transmission/reception function | 3-wire    | UART   | 3-wire    | 3-wire with time-division function | I <sup>2</sup> C bus (multi-master supporting) |
| μPD78054   | ○         | ○      | ○   | ×                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78054Y  | ○         | ○      | ×   | ○                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78064   | ○         | ○      | ○   | ×                    | ×         | ×   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78064Y  | ○         | ○      | ×   | ○                    | ×         | ×   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78078   | ○         | ○      | ○   | ×                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78078Y  | ○         | ○      | ×   | ○                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78083   | ×         | ×      | ×   | ×                    | ×         | ×   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78098   | ○         | ○      | ○   | ×                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |
| μPD780018  | ×         | ×      | ×   | ×                    | ○         | ○   | ×         | ×      | ×         | ○                                  | ×  |
| μPD780018Y   | ×         | ×      | ×   | ×                    | ○         | ○   | ×         | ×      | ×         | ○                                  | ○  |
| μPD780058  | ○         | ○      | ○   | ×                    | ○         | ○   | ○         | ○ Note | ×         | ×                                  | ×  |
| μPD780058Y   | ○         | ○      | ×   | ○                    | ○         | ○   | ○         | ○ Note | ×         | ×                                  | ×  |
| μPD780308  | ○         | ○      | ○   | ×                    | ×         | ×   | ○         | ○ Note | ○         | ×                                  | ×  |
| μPD780308Y   | ○         | ○      | ×   | ○                    | ×         | ×   | ○         | ○ Note | ○         | ×                                  | ×  |
| μPD78058F  | ○         | ○      | ○   | ×                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78058FY   | ○         | ○      | ×   | ○                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78064B  | ○         | ○      | ○   | ×                    | ×         | ×   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78070A  | ○         | ○      | ○   | ×                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78070AY   | ○         | ○      | ×   | ○                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78075B  | ○         | ○      | ○   | ×                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78075BY   | ○         | ○      | ×   | ○                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |
| μPD78098B  | ○         | ○      | ○   | ×                    | ○         | ○   | ○         | ○      | ×         | ×                                  | ×  |

**Note** With time-division transfer function

**Remark** ○: Function provided, ×: Function not provided

The serial interface of the 78K/0 series has a different function depending on the subseries, as shown in Table 8-1. This chapter explains each function and application example of the serial interface. The function supported by each subseries are listed in Table 8-2. For details of application examples of using the serial interface function of a specific subseries, refer to the section or paragraph marked ○ in this table.

★ **Table 8-2. Items Supported by Each Subseries**

| Item<br>Subseries | 8.1.1<br>Communication<br>in 2-wire<br>serial I/O mode | 8.1.2<br>Communication<br>in I <sup>2</sup> C bus<br>mode | 8.2<br>Interface<br>with OSD LSI<br>(μPD6451A) | 8.3<br>Interface<br>in SBI Mode | 8.4<br>Interface in<br>3-Wire Serial I/O<br>Mode | 8.5<br>Interface in<br>Asynchronous<br>Serial Interface<br>(UART) Mode |
|-------------------|--|---|--|---------------------------------|--|--|
| μPD78054          | ○  | —   | ○  | ○                               | ○  | ○  |
| μPD78054Y         | ○  | ○   | ○  | —                               | ○  | ○  |
| μPD78064          | ○  | —   | —  | ○                               | ○  | ○  |
| μPD78064Y         | ○  | ○   | —  | —                               | ○  | ○  |
| μPD78078          | ○  | —   | ○  | ○                               | ○  | ○  |
| μPD78078Y         | ○  | ○   | ○  | —                               | ○  | ○  |
| μPD78083          | —  | —   | —  | —                               | —  | ○  |
| μPD78098          | ○  | —   | ○  | ○                               | ○  | ○  |
| μPD780018         | —  | —   | ○  | —                               | —  | —  |
| μPD780018Y        | —  | —   | ○  | —                               | —  | —  |
| μPD780058         | ○  | —   | ○  | ○                               | ○  | ○  |
| μPD780058Y        | ○  | ○   | ○  | —                               | ○  | ○  |
| μPD780308         | ○  | —   | —  | ○                               | ○  | ○  |
| μPD780308Y        | ○  | ○   | —  | —                               | ○  | ○  |
| μPD78058F         | ○  | —   | ○  | ○                               | ○  | ○  |
| μPD78058FY        | ○  | ○   | ○  | —                               | ○  | ○  |
| μPD78064B         | ○  | —   | —  | ○                               | ○  | ○  |
| μPD78070A         | ○  | —   | ○  | ○                               | ○  | ○  |
| μPD78070AY        | ○  | ○   | ○  | —                               | ○  | ○  |
| μPD78075B         | ○  | —   | ○  | ○                               | ○  | ○  |
| μPD78075BY        | ○  | ○   | ○  | —                               | ○  | ○  |
| μPD78098B         | ○  | —   | ○  | ○                               | ○  | ○  |

The functions and operations of the serial interface are specified by using the following registers:

★

**Table 8-3. Registers of Serial Interface**

| Serial Interface | Register Used   |
|------------------|---|
| Channel 0        | <ul style="list-style-type: none"> <li>• Timer clock select register (TCL3)</li> <li>• Serial operation mode register 0 (CSIM0)</li> <li>• Serial bus interface control register (SBIC)</li> <li>• Interrupt timing specification register (SINT)</li> </ul>  |
| Channel 1        | <ul style="list-style-type: none"> <li>• Timer clock select register (TCL3)</li> <li>• Serial operation mode register 1 (CSIM1)</li> <li>• Automatic data transmission/reception control register (ADTC)</li> <li>• Automatic data transmission/reception interval specification register (ADTI)</li> </ul>   |
| Channel 2        | <ul style="list-style-type: none"> <li>• Serial operation mode register 2 (CSIM2)</li> <li>• Asynchronous serial interface mode register (ASIM)</li> <li>• Asynchronous serial interface status register (ASIS)</li> <li>• Baud rate generator control register (BRGC)</li> <li>• Serial interface pin select register (SIPS)<sup>Note</sup></li> </ul> |

**Note** This register is provided only on the  $\mu$ PD780058, 780058Y, 780308, and 780308Y subseries.

**Remark** This chapter describes the register formats and application examples of serial interface channels 0, 1, and 2. For details of the register formats of channels 3, 4, and 5, refer to the User's Manual of each subseries.

**Figure 8-1. Format of Timer Clock Select Register 3**

( $\mu$ PD78054, 78078, 780058, 78058F, 78075B subseries,  $\mu$ PD78070A)

|        |       |       |       |       |       |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TCL3   | TCL37 | TCL36 | TCL35 | TCL34 | TCL33 | TCL32 | TCL31 | TCL30 | FF43H   | 88H      | R/W |

| TCL33  | TCL32 | TCL31 | TCL30 | Selects serial clock of serial interface channel 0 |                      |                      |
|--------|-------|-------|-------|--|----------------------|----------------------|
|        |       |       |       |  | MCS = 1              | MCS = 0              |
| 0      | 1     | 1     | 0     | $f_{xx}/2$   | Setting prohibited   | $f_x/2^2$ (1.25 MHz) |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$                                       | $f_x/2^2$ (1.25 MHz) | $f_x/2^3$ (625 kHz)  |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$                                       | $f_x/2^3$ (625 kHz)  | $f_x/2^4$ (313 kHz)  |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$                                       | $f_x/2^4$ (313 kHz)  | $f_x/2^5$ (156 kHz)  |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$                                       | $f_x/2^5$ (156 kHz)  | $f_x/2^6$ (78.1 kHz) |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$                                       | $f_x/2^6$ (78.1 kHz) | $f_x/2^7$ (39.1 kHz) |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$                                       | $f_x/2^7$ (39.1 kHz) | $f_x/2^8$ (19.5 kHz) |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$                                       | $f_x/2^8$ (19.5 kHz) | $f_x/2^9$ (9.8 kHz)  |
| Others |       |       |       | Setting prohibited                                 |                      |                      |

| TCL37  | TCL36 | TCL35 | TCL34 | Selects serial clock of serial interface channel 1 |                      |                      |
|--------|-------|-------|-------|--|----------------------|----------------------|
|        |       |       |       |  | MCS = 1              | MCS = 0              |
| 0      | 1     | 1     | 0     | $f_{xx}/2$   | Setting prohibited   | $f_x/2^2$ (1.25 MHz) |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$                                       | $f_x/2^2$ (1.25 MHz) | $f_x/2^3$ (625 kHz)  |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$                                       | $f_x/2^3$ (625 kHz)  | $f_x/2^4$ (313 kHz)  |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$                                       | $f_x/2^4$ (313 kHz)  | $f_x/2^5$ (156 kHz)  |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$                                       | $f_x/2^5$ (156 kHz)  | $f_x/2^6$ (78.1 kHz) |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$                                       | $f_x/2^6$ (78.1 kHz) | $f_x/2^7$ (39.1 kHz) |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$                                       | $f_x/2^7$ (39.1 kHz) | $f_x/2^8$ (19.5 kHz) |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$                                       | $f_x/2^8$ (19.5 kHz) | $f_x/2^9$ (9.8 kHz)  |
| Others |       |       |       | Setting prohibited                                 |                      |                      |

**Caution** Before writing new data to TCL3, stop serial transfer once.

- Remarks**
1.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  2.  $f_x$  : main system clock oscillation frequency
  3. MCS: bit 0 of oscillation mode select register (OSMS)
  4. ( ) : at  $f_x = 5.0$  MHz



Figure 8-2. Format of Timer Clock Select Register 3

( $\mu$ PD78054Y, 78078Y, 780058Y, 78058FY, 78075BY subseries,  $\mu$ PD78070AY)

|        |       |       |       |       |       |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TCL3   | TCL37 | TCL36 | TCL35 | TCL34 | TCL33 | TCL32 | TCL31 | TCL30 | FF43H   | 88H      | R/W |

| TCL33  | TCL32 | TCL31 | TCL30 | Selects serial clock of serial interface channel 0 |                         |                         |   |                      |                      |
|--------|-------|-------|-------|--|-------------------------|-------------------------|---|----------------------|----------------------|
|        |       |       |       | Serial clock in I <sup>2</sup> C bus mode          |                         |                         | Serial clock in 3-wire serial I/O or 2-wire serial I/O mode |                      |                      |
|        |       |       |       |  | MCS = 1                 | MCS = 0                 |   | MCS = 1              | MCS = 0              |
| 0      | 1     | 1     | 0     | $f_{xx}/2^5$                                       | Setting prohibited      | $f_x/2^6$ (78.1 kHz)    | $f_{xx}/2$  | Setting prohibited   | $f_x/2^2$ (1.25 MHz) |
| 0      | 1     | 1     | 1     | $f_{xx}/2^6$                                       | $f_x/2^6$ (78.1 kHz)    | $f_x/2^7$ (39.1 kHz)    | $f_{xx}/2^2$  | $f_x/2^2$ (1.25 MHz) | $f_x/2^3$ (625 kHz)  |
| 1      | 0     | 0     | 0     | $f_{xx}/2^7$                                       | $f_x/2^7$ (39.1 kHz)    | $f_x/2^8$ (19.5 kHz)    | $f_{xx}/2^3$  | $f_x/2^3$ (625 kHz)  | $f_x/2^4$ (313 kHz)  |
| 1      | 0     | 0     | 1     | $f_{xx}/2^8$                                       | $f_x/2^8$ (19.5 kHz)    | $f_x/2^9$ (9.77 kHz)    | $f_{xx}/2^4$  | $f_x/2^4$ (313 kHz)  | $f_x/2^5$ (156 kHz)  |
| 1      | 0     | 1     | 0     | $f_{xx}/2^9$                                       | $f_x/2^9$ (9.77 kHz)    | $f_x/2^{10}$ (4.88 kHz) | $f_{xx}/2^5$  | $f_x/2^5$ (156 kHz)  | $f_x/2^6$ (78.1 kHz) |
| 1      | 0     | 1     | 1     | $f_{xx}/2^{10}$                                    | $f_x/2^{10}$ (4.88 kHz) | $f_x/2^{11}$ (2.44 kHz) | $f_{xx}/2^6$  | $f_x/2^6$ (78.1 kHz) | $f_x/2^7$ (39.1 kHz) |
| 1      | 1     | 0     | 0     | $f_{xx}/2^{11}$                                    | $f_x/2^{11}$ (2.44 kHz) | $f_x/2^{12}$ (1.22 kHz) | $f_{xx}/2^7$  | $f_x/2^7$ (39.1 kHz) | $f_x/2^8$ (19.5 kHz) |
| 1      | 1     | 0     | 1     | $f_{xx}/2^{12}$                                    | $f_x/2^{12}$ (1.22 kHz) | $f_x/2^{13}$ (0.61 kHz) | $f_{xx}/2^8$  | $f_x/2^8$ (19.5 kHz) | $f_x/2^9$ (9.8 kHz)  |
| Others |       |       |       | Setting prohibited                                 |                         |                         |   |                      |                      |

| TCL37  | TCL36 | TCL35 | TCL34 | Selects serial clock of serial interface channel 1 |                      |                      |
|--------|-------|-------|-------|--|----------------------|----------------------|
|        |       |       |       |  | MCS = 1              | MCS = 0              |
| 0      | 1     | 1     | 0     | $f_{xx}/2$   | Setting prohibited   | $f_x/2^2$ (1.25 MHz) |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$                                       | $f_x/2^2$ (1.25 MHz) | $f_x/2^3$ (625 kHz)  |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$                                       | $f_x/2^3$ (625 kHz)  | $f_x/2^4$ (313 kHz)  |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$                                       | $f_x/2^4$ (313 kHz)  | $f_x/2^5$ (156 kHz)  |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$                                       | $f_x/2^5$ (156 kHz)  | $f_x/2^6$ (78.1 kHz) |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$                                       | $f_x/2^6$ (78.1 kHz) | $f_x/2^7$ (39.1 kHz) |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$                                       | $f_x/2^7$ (39.1 kHz) | $f_x/2^8$ (19.5 kHz) |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$                                       | $f_x/2^8$ (19.5 kHz) | $f_x/2^9$ (9.8 kHz)  |
| Others |       |       |       | Setting prohibited                                 |                      |                      |

**Caution** Before writing new data to TCL3, stop serial transfer once.

- Remarks**
1.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  2.  $f_x$  : main system clock oscillation frequency
  3. MCS: bit 0 of oscillation mode select register (OSMS)
  4. ( ) : at  $f_x = 5.0$  MHz

**Figure 8-3. Format of Timer Clock Select Register 3 ( $\mu$ PD78064, 780308, 78064B subseries)**

|        |   |   |   |   |       |       |       |       |         |          |     |
|--------|---|---|---|---|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7 | 6 | 5 | 4 | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TCL3   | 1 | 0 | 0 | 0 | TCL33 | TCL32 | TCL31 | TCL30 | FF43H   | 88H      | R/W |

| TCL33  | TCL32 | TCL31 | TCL30 | Selects serial clock of serial interface channel 0 |                      |                      |
|--------|-------|-------|-------|--|----------------------|----------------------|
|        |       |       |       |  | MCS = 1              | MCS = 0              |
| 0      | 1     | 1     | 0     | $f_{xx}/2$   | Setting prohibited   | $f_x/2^2$ (1.25 MHz) |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$                                       | $f_x/2^2$ (1.25 MHz) | $f_x/2^3$ (625 kHz)  |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$                                       | $f_x/2^3$ (625 kHz)  | $f_x/2^4$ (313 kHz)  |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$                                       | $f_x/2^4$ (313 kHz)  | $f_x/2^5$ (156 kHz)  |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$                                       | $f_x/2^5$ (156 kHz)  | $f_x/2^6$ (78.1 kHz) |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$                                       | $f_x/2^6$ (78.1 kHz) | $f_x/2^7$ (39.1 kHz) |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$                                       | $f_x/2^7$ (39.1 kHz) | $f_x/2^8$ (19.5 kHz) |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$                                       | $f_x/2^8$ (19.5 kHz) | $f_x/2^9$ (9.8 kHz)  |
| Others |       |       |       | Setting prohibited                                 |                      |                      |

- Cautions**
1. Clear bits 4 through 6 to 0 and set bit 7 to 1.
  2. Before writing new data to TCL3, stop serial transfer once.

- Remarks**
1.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  2.  $f_x$  : main system clock oscillation frequency
  3. MCS: bit 0 of oscillation mode select register (OSMS)
  4. ( ) : at  $f_x = 5.0$  MHz

Figure 8-4. Format of Timer Clock Select Register 3 ( $\mu$ PD78064Y, 780308Y subseries)

|        |   |   |   |   |       |       |       |       |         |          |     |
|--------|---|---|---|---|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7 | 6 | 5 | 4 | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TCL3   | 1 | 0 | 0 | 0 | TCL33 | TCL32 | TCL31 | TCL30 | FF43H   | 88H      | R/W |

| TCL33  | TCL32 | TCL31 | TCL30 | Selects serial clock of serial interface channel 0 |                         |                         |   |                      |                      |
|--------|-------|-------|-------|--|-------------------------|-------------------------|---|----------------------|----------------------|
|        |       |       |       | Serial clock in I <sup>2</sup> C bus mode          |                         |                         | Serial clock in 3-wire serial I/O or 2-wire serial I/O mode |                      |                      |
|        |       |       |       |  | MCS = 1                 | MCS = 0                 |   | MCS = 1              | MCS = 0              |
| 0      | 1     | 1     | 0     | $f_{xx}/2^5$                                       | Setting prohibited      | $f_x/2^6$ (78.1 kHz)    | $f_{xx}/2$  | Setting prohibited   | $f_x/2^2$ (1.25 MHz) |
| 0      | 1     | 1     | 1     | $f_{xx}/2^6$                                       | $f_x/2^6$ (78.1 kHz)    | $f_x/2^7$ (39.1 kHz)    | $f_{xx}/2^2$  | $f_x/2^2$ (1.25 MHz) | $f_x/2^3$ (625 kHz)  |
| 1      | 0     | 0     | 0     | $f_{xx}/2^7$                                       | $f_x/2^7$ (39.1 kHz)    | $f_x/2^8$ (19.5 kHz)    | $f_{xx}/2^3$  | $f_x/2^3$ (625 kHz)  | $f_x/2^4$ (313 kHz)  |
| 1      | 0     | 0     | 1     | $f_{xx}/2^8$                                       | $f_x/2^8$ (19.5 kHz)    | $f_x/2^9$ (9.77 kHz)    | $f_{xx}/2^4$  | $f_x/2^4$ (313 kHz)  | $f_x/2^5$ (156 kHz)  |
| 1      | 0     | 1     | 0     | $f_{xx}/2^9$                                       | $f_x/2^9$ (9.77 kHz)    | $f_x/2^{10}$ (4.88 kHz) | $f_{xx}/2^5$  | $f_x/2^5$ (156 kHz)  | $f_x/2^6$ (78.1 kHz) |
| 1      | 0     | 1     | 1     | $f_{xx}/2^{10}$                                    | $f_x/2^{10}$ (4.88 kHz) | $f_x/2^{11}$ (2.44 kHz) | $f_{xx}/2^6$  | $f_x/2^6$ (78.1 kHz) | $f_x/2^7$ (39.1 kHz) |
| 1      | 1     | 0     | 0     | $f_{xx}/2^{11}$                                    | $f_x/2^{11}$ (2.44 kHz) | $f_x/2^{12}$ (1.22 kHz) | $f_{xx}/2^7$  | $f_x/2^7$ (39.1 kHz) | $f_x/2^8$ (19.5 kHz) |
| 1      | 1     | 0     | 1     | $f_{xx}/2^{12}$                                    | $f_x/2^{12}$ (1.22 kHz) | $f_x/2^{13}$ (0.61 kHz) | $f_{xx}/2^8$  | $f_x/2^8$ (19.5 kHz) | $f_x/2^9$ (9.8 kHz)  |
| Others |       |       |       | Setting prohibited                                 |                         |                         |   |                      |                      |

- Cautions**
1. Clear bits 4 through 6 to 0 and set bit 7 to 1.
  2. Before writing new data to TCL3, stop serial transfer once.

- Remarks**
1.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  2.  $f_x$  : main system clock oscillation frequency
  3. MCS: bit 0 of oscillation mode select register (OSMS)
  4. ( ) : at  $f_x = 5.0$  MHz

Figure 8-5. Format of Timer Clock Select Register 3 ( $\mu$ PD78098, 78098B subseries)

|        |       |       |       |       |       |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| TCL3   | TCL37 | TCL36 | TCL35 | TCL34 | TCL33 | TCL32 | TCL31 | TCL30 | FF43H   | 88H      | R/W |

| TCL33  | TCL32 | TCL31 | TCL30 | Selects serial clock of serial interface channel 0 |
|--------|-------|-------|-------|--|
| 0      | 1     | 1     | 0     | $f_{xx}/2$ <sup>Note</sup>                         |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$ (1.0 MHz)                             |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$ (500 kHz)                             |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$ (250 kHz)                             |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$ (125 kHz)                             |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$ (62.5 kHz)                            |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$ (31.3 kHz)                            |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$ (15.6 kHz)                            |
| Others |       |       |       | Setting prohibited                                 |

| TCL37  | TCL36 | TCL35 | TCL34 | Selects serial clock of serial interface channel 1 |
|--------|-------|-------|-------|--|
| 0      | 1     | 1     | 0     | $f_{xx}/2$ <sup>Note</sup>                         |
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$ (1.0 MHz)                             |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$ (500 kHz)                             |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$ (250 kHz)                             |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$ (125 kHz)                             |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$ (62.5 kHz)                            |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$ (31.3 kHz)                            |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$ (15.6 kHz)                            |
| Others |       |       |       | Setting prohibited                                 |

**Note** Can be set only when the main system clock frequency is 5.0 MHz or less.

**Caution** Before writing new data to TCL3, stop serial transfer once.

**Remarks** 1.  $f_{xx}$  : main system clock frequency  
 2. ( ) : at  $f_{xx} = 4.0$  MHz

★

Figure 8-6. Format of Timer Clock Select Register 3 ( $\mu$ PD780018, 780018Y subseries)

|        |       |       |       |       |   |   |   |   |         |          |     |
|--------|-------|-------|-------|-------|---|---|---|---|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3 | 2 | 1 | 0 | Address | At reset | R/W |
| TCL3   | TCL37 | TCL36 | TCL35 | TCL34 | 1 | 0 | 0 | 0 | FF43H   | 88H      | R/W |

| TCL37  | TCL36 | TCL35 | TCL34 | Selects serial clock of serial interface channel 1 |                      |
|--------|-------|-------|-------|--|----------------------|
| 0      | 1     | 1     | 1     | $f_{xx}/2^2$                                       | $f_x/2^2$ (1.25 MHz) |
| 1      | 0     | 0     | 0     | $f_{xx}/2^3$                                       | $f_x/2^3$ (625 kHz)  |
| 1      | 0     | 0     | 1     | $f_{xx}/2^4$                                       | $f_x/2^4$ (313 kHz)  |
| 1      | 0     | 1     | 0     | $f_{xx}/2^5$                                       | $f_x/2^5$ (156 kHz)  |
| 1      | 0     | 1     | 1     | $f_{xx}/2^6$                                       | $f_x/2^6$ (78.1 kHz) |
| 1      | 1     | 0     | 0     | $f_{xx}/2^7$                                       | $f_x/2^7$ (39.1 kHz) |
| 1      | 1     | 0     | 1     | $f_{xx}/2^8$                                       | $f_x/2^8$ (19.5 kHz) |
| Others |       |       |       | Setting prohibited                                 |                      |

**Caution** Before writing new data to TCL3, stop serial transfer once.

- Remarks**
1.  $f_{xx}$  : main system clock frequency ( $f_x$ )
  2.  $f_x$  : main system clock oscillation frequency
  3. ( ) : at  $f_x = 5.0$  MHz

Figure 8-7. Format of Serial Operating Mode Register 0

( $\mu$ PD78054, 78064, 78078, 78098, 780058, 780308, 78058F, 78064B, 78075B, 78098B subseries,  $\mu$ PD78070A)(1/2)

|        |           |     |     |            |            |            |            |            |         |          |                       |
|--------|-----------|-----|-----|------------|------------|------------|------------|------------|---------|----------|-----------------------|
| Symbol | 7         | 6   | 5   | 4          | 3          | 2          | 1          | 0          | Address | At reset | R/W                   |
| CSIM0  | CSIE<br>0 | COI | WUP | CSIM<br>04 | CSIM<br>03 | CSIM<br>02 | CSIM<br>01 | CSIM<br>00 | FF60H   | 00H      | R/W <sup>Note 1</sup> |

|     |            |            |   |  |  |  |  |  |  |  |  |  |
|-----|------------|------------|---|--|--|--|--|--|--|--|--|--|
| R/W | CSIM<br>01 | CSIM<br>00 | Selects clock of serial interface channel 0                                 |  |  |  |  |  |  |  |  |  |
|     | 0          | ×          | Clock externally input to $\overline{\text{SCK0}}$ pin                      |  |  |  |  |  |  |  |  |  |
|     | 1          | 0          | Output of 8-bit timer register 2 (TM2)                                      |  |  |  |  |  |  |  |  |  |
|     | 1          | 1          | Clock specified by bits 0 through 3 of timer clock select register 3 (TCL3) |  |  |  |  |  |  |  |  |  |

| R/W | CSIM<br>04 | CSIM<br>03 | CSIM<br>02 | PM25        | P25         | PM26        | P26         | PM27 | P27 | Operation mode | First bit | Function of<br>SI0/SB0/P25 pin   | Function of<br>SO0/SB1/P26 pin  | Function of<br>$\overline{\text{SCK0}}$ /P27 pin     |
|-----|------------|------------|------------|-------------|-------------|-------------|-------------|------|-----|----------------|-----------|----------------------------------|---------------------------------|--|
|     | 0          | ×          | 0          | Note 2<br>1 | Note 2<br>× | 0           | 0           | 0    | 1   | 3-wire serial  | MSB       | SI0 <sup>Note 2</sup><br>(input) | SO0<br>(CMOS output)            | $\overline{\text{SCK0}}$<br>(CMOS I/O)               |
|     |            |            | 1          | 1           | ×           | 0           | 0           | 0    | 1   | I/O mode       | LSB       |                                  |                                 |  |
|     | 1          | 0          | 0          | Note 3<br>× | Note 3<br>× | 0           | 0           | 0    | 1   | SBI mode       | MSB       | P25<br>(CMOS I/O)                | SB1<br>(N-ch open drain<br>I/O) | $\overline{\text{SCK0}}$<br>(CMOS I/O)               |
|     |            |            | 1          | 0           | 0           | Note 3<br>× | Note 3<br>× | 0    | 1   |                |           | SB0<br>(N-ch open drain<br>I/O)  | P26<br>(CMOS I/O)               |  |
|     | 1          | 1          | 0          | Note 3<br>× | Note 3<br>× | 0           | 0           | 0    | 1   | 2-wire serial  | MSB       | P25<br>(CMOS I/O)                | SB1<br>(N-ch open drain<br>I/O) | $\overline{\text{SCK0}}$<br>(N-ch open drain<br>I/O) |
|     |            |            | 1          | 0           | 0           | Note 3<br>× | Note 3<br>× | 0    | 1   | I/O mode       |           |                                  |                                 |  |

|     |     |   |  |  |  |  |  |  |  |  |  |  |
|-----|-----|---|--|--|--|--|--|--|--|--|--|--|
| R/W | WUP | Controls wake-up function <sup>Note 4</sup>   |  |  |  |  |  |  |  |  |  |  |
|     | 0   | Generates interrupt request signal in all modes each time serial transfer is executed   |  |  |  |  |  |  |  |  |  |  |
|     | 1   | Generates interrupt request signal when address received after bus has been released (when CMDD = RELD = 1) coincides with data of slave address register in SBI mode |  |  |  |  |  |  |  |  |  |  |

**Notes 1.** Bit 6 (COI) is a read-only bit.

2. When only the transmission function is used, this pin can be used as P25 (CMOS I/O).

3. These pins can be used as port pins.

★ 4. When using the wake-up function (WUP = 1), clear bit 5 (SIC) of the interrupt timing specification register (SINT) to 0.

★ **Caution** Do not change the operation mode (3-wire serial I/O/2-wire serial I/O/SBI) while the operation of the serial interface channel 0 is enabled. To change the operation mode, stop the serial operation.

**Remark** × : don't care

PMxx: Port mode register

Pxx : Output latch of port

**Figure 8-7. Format of Serial Operating Mode Register 0**

( $\mu$ PD78054, 78064, 78078, 78098, 780058, 780308, 78058F, 78064B, 78075B, 78098B subseries,  $\mu$ PD78070A)(2/2)

|     |       |   |
|-----|-------|---|
| R   | COI   | Slave address comparison result flag <sup>Note</sup>                                    |
|     | 0     | Data of slave address register does not coincide with data of serial I/O shift register |
|     | 1     | Data of slave address register coincides with data of serial I/O shift register         |
| R/W | CSIE0 | Controls operation of serial interface channel 0  |
|     | 0     | Stops operation   |
|     | 1     | Enables operation   |

**Note** COI is 0 when CSIE0 = 0.

- ★ **Caution** Do not change the operation mode (3-wire serial I/O/2-wire serial I/O/SBI) while the operation of the serial interface channel 0 is enabled. To change the operation mode, stop the serial operation.

**Figure 8-8. Format of Serial Operating Mode Register 0**  
 (μPD78054Y, 78064Y, 78078Y, 780058Y, 780308Y, 78058FY, 78075BY  
 subseries, μPD78070AY) (1/2)

|        |           |     |     |            |            |            |            |            |         |          |                       |
|--------|-----------|-----|-----|------------|------------|------------|------------|------------|---------|----------|-----------------------|
| Symbol | 7         | 6   | 5   | 4          | 3          | 2          | 1          | 0          | Address | At reset | R/W                   |
| CSIM0  | CSIE<br>0 | COI | WUP | CSIM<br>04 | CSIM<br>03 | CSIM<br>02 | CSIM<br>01 | CSIM<br>00 | FF60H   | 00H      | R/W <sup>Note 1</sup> |

|     |            |            |   |  |  |  |  |  |  |  |  |  |
|-----|------------|------------|---|--|--|--|--|--|--|--|--|--|
| R/W | CSIM<br>01 | CSIM<br>00 | Selects clock of serial interface channel 0                                 |  |  |  |  |  |  |  |  |  |
|     | 0          | ×          | Clock externally input to SCK0/SCL pin                                      |  |  |  |  |  |  |  |  |  |
|     | 1          | 0          | Output of 8-bit timer register 2 (TM2) <sup>Note 2</sup>                    |  |  |  |  |  |  |  |  |  |
|     | 1          | 1          | Clock specified by bits 0 through 3 of timer clock select register 3 (TCL3) |  |  |  |  |  |  |  |  |  |

|     |            |            |            |                        |                        |                        |                        |      |     |   |            |                                      |                                     |                                      |
|-----|------------|------------|------------|------------------------|------------------------|------------------------|------------------------|------|-----|---|------------|--------------------------------------|-------------------------------------|--------------------------------------|
| R/W | CSIM<br>04 | CSIM<br>03 | CSIM<br>02 | PM25                   | P25                    | PM26                   | P26                    | PM27 | P27 | Operation mode  | First bit  | Function of<br>SI0/SB0/SDA0/P25 pin  | Function of<br>SO0/SB1/SDA1/P26 pin | Function of<br>SCK0/SCL/P27 pin      |
|     | 0          | ×          | 0          | <sup>Note 3</sup><br>1 | <sup>Note 3</sup><br>× | 0                      | 0                      | 0    | 1   | 3-wire serial<br>I/O mode                                 | MSB<br>LSB | SI0 <sup>Note 3</sup><br>(input)     | SO0<br>(CMOS output)                | SCK0<br>(CMOS I/O)                   |
|     | 1          | 1          | 0          | <sup>Note 4</sup><br>× | <sup>Note 4</sup><br>× | 0                      | 0                      | 0    | 1   | 2-wire serial<br>I/O mode or<br>I <sup>2</sup> C bus mode | MSB        | P25<br>(CMOS I/O)                    | SB1<br>(N-ch open drain<br>I/O)     | SCK0/SCL<br>(N-ch open drain<br>I/O) |
|     |            |            | 1          | 0                      | 0                      | <sup>Note 4</sup><br>× | <sup>Note 4</sup><br>× | 0    | 1   |   |            | SB0/SDA0<br>(N-ch open drain<br>I/O) | P26<br>(CMOS I/O)                   |                                      |

|     |     |   |  |  |  |  |  |  |  |  |  |  |
|-----|-----|---|--|--|--|--|--|--|--|--|--|--|
| R/W | WUP | Controls wake-up function <sup>Note 5</sup>   |  |  |  |  |  |  |  |  |  |  |
|     | 0   | Generates interrupt request signal in all modes each time serial transfer is executed   |  |  |  |  |  |  |  |  |  |  |
|     | 1   | Generates interrupt request signal when address received after start condition has been detected (when CMDD = 1) coincides with data of slave address register in I <sup>2</sup> C mode |  |  |  |  |  |  |  |  |  |  |

**Notes 1.** Bit 6 (COI) is a read-only bit.

**2.** In the I<sup>2</sup>C bus mode, the clock frequency is 1/16 of the clock frequency output by TO2

**3.** When only the transmission function is used, this pin can be used as P25 (CMOS I/O).

**4.** These pins can be used as port pins.

★ **5.** When using the wake-up function (WUP = 1), clear bit 5 (SIC) of the interrupt timing specification register (SINT) to 0. While WUP = 1, do not execute an instruction that writes data to the I/O shift register 0 (SIO0).

★ **Caution** Do not change the operation mode (3-wire serial I/O/2-wire serial I/O/I<sup>2</sup>C bus) while the operation of the serial interface channel 0 is enabled. To change the operation mode, stop the serial operation.

**Remark** × : don't care  
 PMxx: Port mode register  
 Pxx : Output latch of port



**Figure 8-8. Format of Serial Operating Mode Register 0**

( $\mu$ PD78054Y, 78064Y, 78078Y, 780058Y, 780308Y, 78058FY, 78075BY subseries,  $\mu$ PD78070AY) (2/2)

|     |       |   |
|-----|-------|---|
| R   | COI   | Slave address comparison result flag <sup>Note</sup>                                    |
|     | 0     | Data of slave address register does not coincide with data of serial I/O shift register |
|     | 1     | Data of slave address register coincides with data of serial I/O shift register         |
| R/W | CSIE0 | Controls operation of serial interface channel 0  |
|     | 0     | Stops operation   |
|     | 1     | Enables operation   |

**Note** COI is 0 when CSIE0 = 0.

- ★ **Caution** Do not change the operation mode (3-wire serial I/O/2-wire serial I/O/I<sup>2</sup>C bus) while the operation of the serial interface channel 0 is enabled. To change the operation mode, stop the serial operation.

**Figure 8-9. Format of Serial Bus Interface Control Register**

( $\mu$ PD78054, 78064, 78078, 78098, 780058, 780308, 78058F, 78064B, 78075B, 78098B subseries,  $\mu$ PD78070A) (1/2)

| Symbol | 7    | 6  | 5    | 4    | 3    | 2    | 1   | 0    | Address | At reset | R/W                 |
|--------|------|--|------|------|------|------|---|------|---------|----------|---------------------|
| SBIC   | BSYE | ACKD   | ACKE | ACKT | CMDD | RELD | CMDT  | RELT | FF61H   | 00H      | R/W <sup>Note</sup> |
| R/W    | RELT | Used to output bus release signal.<br>When RELT = 1, SO latch is set to 1. After SO latch has been set, this bit is automatically cleared to 0. It is also cleared to 0 when CSIE = 0.   |      |      |      |      |   |      |         |          |                     |
| R/W    | CMDT | Used to output command signal.<br>When CMDT = 1, SO latch is cleared to 0. After SO latch has been cleared, this bit is automatically cleared to 0. It is also cleared to 0 when CSIE0 = 0.  |      |      |      |      |   |      |         |          |                     |
| R      | RELD | Bus release detection  |      |      |      |      |   |      |         |          |                     |
|        |      | Clear condition (RELD = 0)   |      |      |      |      | Set condition (RELD = 1)  |      |         |          |                     |
|        |      | <ul style="list-style-type: none"> <li>On execution of transfer start instruction</li> <li>If values of SIO0 and SVA do not coincide when address is received</li> <li>When CSIE0 = 0</li> <li>At <math>\overline{\text{RESET}}</math> input</li> </ul>  |      |      |      |      | <ul style="list-style-type: none"> <li>When bus release signal (REL) is detected</li> </ul> |      |         |          |                     |
| R      | CMDD | Command detection  |      |      |      |      |   |      |         |          |                     |
|        |      | Clear condition (CMDD = 0)   |      |      |      |      | Set condition (CMDD = 1)  |      |         |          |                     |
|        |      | <ul style="list-style-type: none"> <li>On execution of transfer start instruction</li> <li>When bus release signal (REL) is detected</li> <li>When CSIE0 = 0</li> <li>At <math>\overline{\text{RESET}}</math> input</li> </ul>   |      |      |      |      | <ul style="list-style-type: none"> <li>When command signal (CMD) is detected</li> </ul>     |      |         |          |                     |
| R/W    | ACKT | Outputs acknowledge signal in synchronization with falling edge of $\overline{\text{SCK0}}$ clock immediately after instruction that sets this bit to 1 has been executed. After acknowledge signal has been output, this bit is automatically cleared to 0. ACEK is cleared to 0.<br>This bit is also cleared to 0 when transfer of serial interface is started and when CSIE0 = 0. |      |      |      |      |   |      |         |          |                     |

**Note** Bits 2, 3, and 6 (RELD, CMDD, and ACKD) are read-only bits.

**Remarks 1.** Bits 0, 1, and 4 (RELD, CMDT, and ACKT) are cleared to 0 when they are read after data has been set.

**2.** CSIE0: Bit 7 of the serial operating mode register 0 (CSIM0)

**Figure 8-9. Format of Serial Bus Interface Control Register**  
 ( $\mu$ PD78054, 78064, 78078, 78098, 780058, 780308, 78058F, 78064B, 78075B, 78098B subseries,  $\mu$ PD78070A) (2/2)

|     |                      |   |   |
|-----|----------------------|---|---|
| R/W | ACKE                 | Controls acknowledge signal output  |   |
|     | 0                    | Disables automatic output of acknowledge signal (output by ACKT is enabled)   |   |
|     | 1                    | Before completion of transfer   | Acknowledge signal is output in synchronization with falling edge of 9th clock of SCK0 (automatically output when ACKE = 1)   |
|     |                      | After completion of transfer  | Acknowledge signal is output in synchronization with falling edge of $\overline{\text{SCK0}}$ clock immediately after instruction that sets this bit to 1 has been executed (automatically output when ACKE = 1). However, this bit is not automatically cleared to 0 after acknowledge signal has been output. |
| R   | ACKD                 | Acknowledge detection   |   |
|     |                      | Clear condition (ACKD = 0)  | Set condition (ACKD = 1)  |
|     |                      | <ul style="list-style-type: none"> <li>Falling edge of <math>\overline{\text{SCK0}}</math> clock immediately after busy mode has been released after execution of transfer start instruction</li> <li>When CSIE0 = 0</li> <li>At RESET input</li> </ul> | <ul style="list-style-type: none"> <li>When acknowledge signal (<math>\overline{\text{ACK}}</math>) is detected at rising edge of SCK0 clock after completion of transfer</li> </ul>  |
| R/W | BSYE <sup>Note</sup> | Controls output of synchronization busy signal  |   |
|     | 0                    | Disables output of busy signal in synchronization with falling edge of $\overline{\text{SCK0}}$ clock immediately after instruction that clears this bit to 0 has been executed   |   |
|     | 1                    | Outputs busy signal at falling edge of $\overline{\text{SCK0}}$ clock following acknowledge signal  |   |

**Note** The busy mode can be released by starting serial interface transfer and receiving of an address signal. However, the BSYE flag is not cleared to 0.

**Remark** CSIE0: Bit 7 of the serial operating mode register 0 (CSIM0)

**Figure 8-10. Format of Serial Bus Interface Control Register**  
 ( $\mu$ PD78054Y, 78064Y, 78078Y, 780058Y, 780308Y, 78058FY, 78075BY  
 subseries,  $\mu$ PD78070AY) (1/2)

| Symbol | 7    | 6  | 5    | 4    | 3    | 2    | 1  | 0    | Address | At reset | R/W                 |
|--------|------|--|------|------|------|------|--|------|---------|----------|---------------------|
| SBIC   | BSYE | ACKD   | ACKE | ACKT | CMDD | RELD | CMDT   | RELT | FF61H   | 00H      | R/W <sup>Note</sup> |
| R/W    | RELT | Used to output stop condition.<br>When RELT = 1, SO latch is set to 1. After SO latch has been set, this bit is automatically cleared to 0. It is also cleared to 0 when CSIE0 = 0.  |      |      |      |      |  |      |         |          |                     |
| R/W    | CMDT | Used to output start condition.<br>When CMDT = 1, SO latch is cleared to 0. After SO latch has been cleared, this bit is automatically cleared to 0. It is also cleared to 0 when CSIE0 = 0.   |      |      |      |      |  |      |         |          |                     |
| R      | RELD | Stop condition detection   |      |      |      |      |  |      |         |          |                     |
|        |      | Clear condition (RELD = 0)   |      |      |      |      | Set condition (RELD = 1)   |      |         |          |                     |
|        |      | <ul style="list-style-type: none"> <li>On execution of transfer start instruction</li> <li>If values of SIO0 and SVA do not coincide when address is received</li> <li>When CSIE0 = 0</li> <li>At <math>\overline{\text{RESET}}</math> input</li> </ul>                            |      |      |      |      | <ul style="list-style-type: none"> <li>Stop condition is detected</li> </ul>       |      |         |          |                     |
| R      | CMDD | Start condition detection  |      |      |      |      |  |      |         |          |                     |
|        |      | Clear condition (CMDD = 0)   |      |      |      |      | Set condition (CMDD = 1)   |      |         |          |                     |
|        |      | <ul style="list-style-type: none"> <li>On execution of transfer start instruction</li> <li>When stop condition is detected</li> <li>When CSIE0 = 0</li> <li>At <math>\overline{\text{RESET}}</math> input</li> </ul>   |      |      |      |      | <ul style="list-style-type: none"> <li>When start condition is detected</li> </ul> |      |         |          |                     |
| R/W    | ACKT | Makes SDA0 (SDA1) low immediately after instruction that sets this bit to 1 (ACKT = 1) until next SCL falls. Used to generate $\overline{\text{ACK}}$ signal by software when 8-clock wait is selected.<br>Cleared to 0 when transfer by serial interface is started and CSIE0 = 0 |      |      |      |      |  |      |         |          |                     |

**Note** Bits 2, 3, and 6 (RELD, CMDD, and ACKD) are read-only bits.

**Remark** CSIE0: Bit 7 of the serial operating mode register 0 (CSIM0)

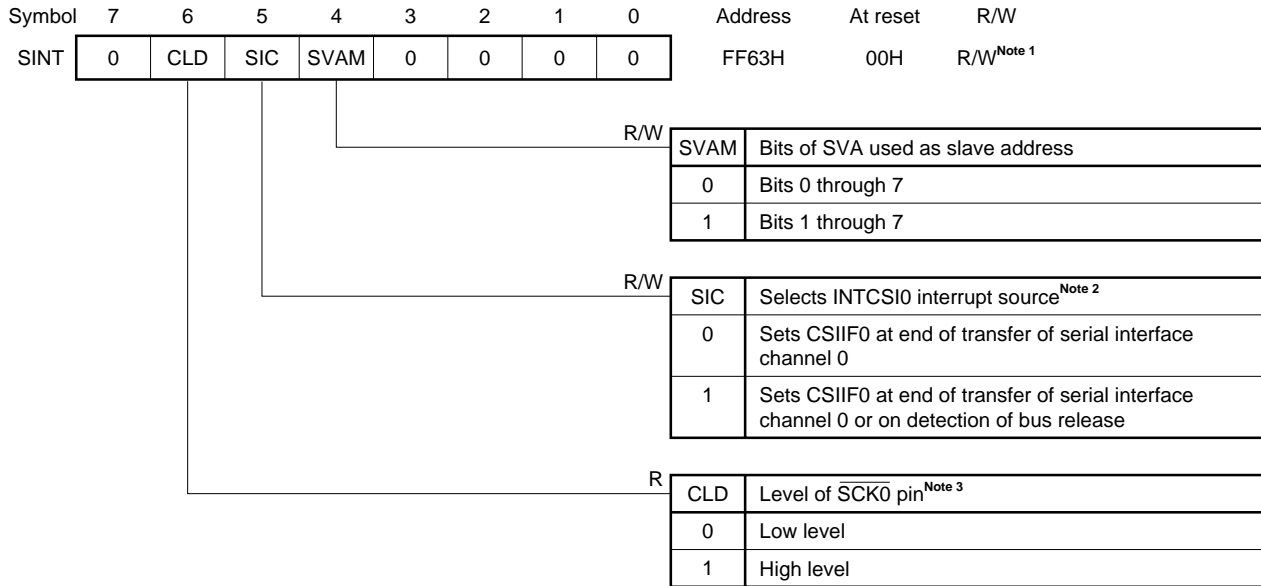
**Figure 8-10. Format of Serial Bus Interface Control Register**  
 (μPD78054Y, 78064Y, 78078Y, 780058Y, 780308Y, 78058FY, 78075BY  
 subseries, μPD78070AY) (2/2)

|     |                        |   |  |
|-----|------------------------|---|--|
| R/W | ACKE                   | Controls automatic output of acknowledge signal <sup>Note 1</sup>   |  |
|     | 0                      | Disables automatic output of acknowledge signal (output by ACKT is enabled). Used for transmission or reception with 8-clock wait selected <sup>Note 2</sup> .  |  |
|     | 1                      | Enables automatic output of acknowledge signal. Acknowledge signal is output in synchronization with falling edge of 9th clock of $\overline{\text{SCL}}$ (automatically output when ACKE = 1). After output, this bit is not automatically cleared to 0. Used for reception when 9-clock wait is selected. |  |
| R   | ACKD                   | Acknowledge detection   |  |
|     |                        | Clear condition (ACKD = 0)  | Set condition (ACKD = 1)   |
|     |                        | <ul style="list-style-type: none"> <li>• On execution of transfer start instruction</li> <li>• When CSIE0 = 0</li> <li>• At RESET input</li> </ul>  | <ul style="list-style-type: none"> <li>• When acknowledge signal is detected at rising edge of SCL clock after completion of transfer</li> </ul> |
| R/W | BSYE <sup>Note 3</sup> | Controls transmission N-ch open drain output in I <sup>2</sup> C bus mode <sup>Note 4</sup>   |  |
|     | 0                      | Enables output (transmission)   |  |
|     | 1                      | Disables output (reception)   |  |

- Notes**
1. Set this bit before starting transfer.
  2. Output the acknowledge signal on reception by using ACKT when 8-clock wait is selected.
  3. The wait status can be released by starting transfer of serial interface or receiving an address signal. However, BSYE is not cleared to 0.
  4. Be sure to set BSYE to 1 when using the wake-up function.

**Remark** CSIE0: Bit 7 of the serial operating mode register 0 (CSIM0)

**Figure 8-11. Format of Interrupt Timing Specification Register**  
 (μPD78054, 78064, 78078, 78098, 780058, 780308, 78058F, 78064B, 78075B,  
 78098B subseries, μPD78070A)



- Notes**
1. Bit 6 (CLD) is a read-only bit.
  2. Clear SIC to 0 when using the wake-up function in the SBI mode.
  3. CLD is 0 when CSIE0 = 0.

**Caution** Be sure to clear bits 0 through 3 to 0.

**Remark** SVA : slave address register  
 CSIF0: interrupt request flag corresponding to INTCSI0  
 CSIE0 : bit 7 of the serial operating mode register 0 (CSIM0)

**Figure 8-12. Format of Interrupt Timing Specification Register**  
 (μPD78054Y, 78064Y, 78078Y, 780058Y, 780308Y, 78058FY, 78075BY  
 subseries, μPD78070AY) (1/2)

| Symbol | 7 | 6   | 5   | 4    | 3   | 2    | 1    | 0    | Address | At reset | R/W                   |
|--------|---|-----|-----|------|-----|------|------|------|---------|----------|-----------------------|
| SINT   | 0 | CLD | SIC | SVAM | CLC | WREL | WAT1 | WAT0 | FF63H   | 00H      | R/W <sup>Note 1</sup> |

| R/W | WAT1 | WAT0 | Controls wait and interrupt processing request  |
|-----|------|------|---|
|     | 0    | 0    | Generates interrupt request at rising edge of 8th clock of $\overline{\text{SCK0}}$ (clock output goes into high-impedance state)   |
|     | 0    | 1    | Setting prohibited  |
|     | 1    | 0    | Used in I <sup>2</sup> C bus mode (8-clock wait).<br>Generates interrupt processing request at rising edge of 8th clock of SCL (master makes SCL output low and waits after outputting 8 clocks. Slave makes SCL pin low and requests for wait after inputting 8 clocks). |
|     | 1    | 1    | Used in I <sup>2</sup> C bus mode (9-clock wait).<br>Generates interrupt processing request at rising edge of 9th clock of SCL (master makes SCL output low and waits after outputting 9 clocks. Slave makes SCL pin low and requests for wait after inputting 9 clocks). |

| R/W | WREL | Controls wait release   |
|-----|------|---|
|     | 0    | Wait release status   |
|     | 1    | Releases wait status.<br>After wait status has been released, this bit is automatically cleared to 0 (used to release wait status set by WAT1 and WAT0) |

| R/W | CLC | Controls clock level <sup>Note 2</sup>  |
|-----|-----|---|
|     | 0   | Used in I <sup>2</sup> C bus mode.<br>Makes output level of SCL pin low when serial transfer is not executed  |
|     | 1   | Used in I <sup>2</sup> C bus mode.<br>Makes output level of SCL pin high impedance when serial transfer is not executed (clock line goes high).<br>Used by master to generate start/stop condition. |

- Notes**
1. Bit 6 (CLD) is a read-only bit.
  2. Clear CLC to 0 when the I<sup>2</sup>C bus mode is not used.

**Figure 8-12. Format of Interrupt Timing Specification Register**  
 ( $\mu$ PD78054Y, 78064Y, 78078Y, 780058Y, 780308Y, 78058FY, 78075BY  
 subseries,  $\mu$ PD78070AY) (2/2)

|     |      |  |
|-----|------|--|
| R/W | SVAM | Bits of SVA used as slave address  |
|     | 0    | Bits 0 through 7   |
|     | 1    | Bits 1 through 7   |
| R/W | SIC  | Selects INTCSI0 interrupt source <sup>Note 1</sup>   |
|     | 0    | Sets CSIF0 to 1 at end of transfer of serial interface channel 0                                   |
|     | 1    | Sets CSIF0 to 1 at end of transfer of serial interface channel 0 or on detection of stop condition |
| R/W | CLD  | Level of $\overline{\text{SCK0/SCL/P27}}$ pin <sup>Note 2</sup>                                    |
|     | 0    | Low level  |
|     | 1    | High level   |

**Notes** 1. Sets SIC to 1 when using the wake-up function in the I<sup>2</sup>C mode.

2. CLD is 0 when CSIE0 = 0.

**Remark** SVA : slave address register

CSIF0: interrupt request flag corresponding to INTCSI0

CSIE0 : bit 7 of the serial operating mode register 0 (CSIM0)



**Figure 8-13. Format of Serial Operating Mode Register 1**

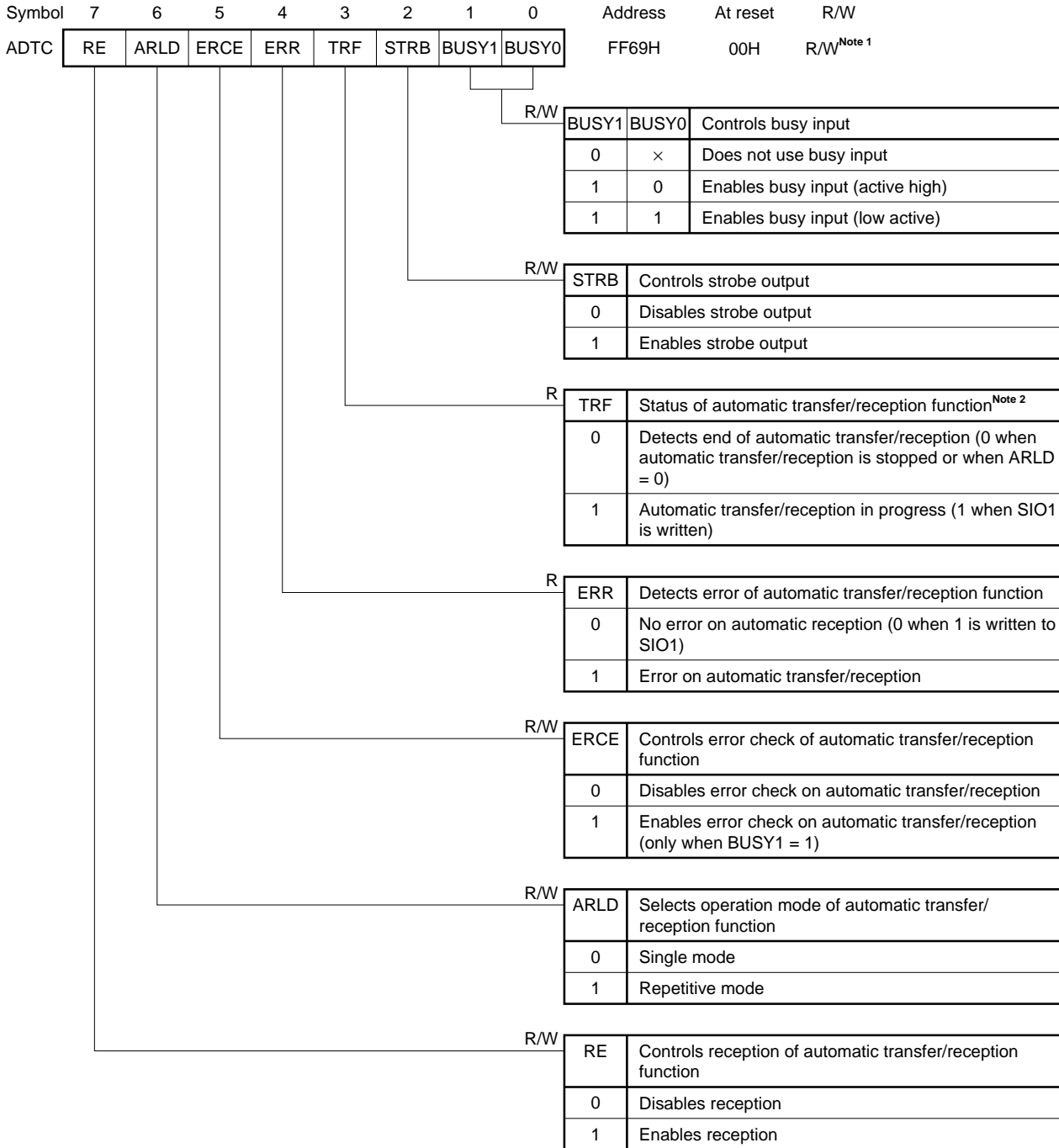
( $\mu$ PD78054, 78054Y, 78078, 78078Y, 78098, 780018, 780018Y, 780058, 780058Y, 78058F, 78058FY, 78075B, 78075BY, 78098B subseries,  $\mu$ PD78070A, 78070AY)

| Symbol     | 7          | 6   | 5   | 4           | 3           | 2                   | 1           | 0                             | Address                                       | At reset                         | R/W                     |   |
|------------|------------|---|---|-------------|-------------|---------------------|-------------|-------------------------------|---|----------------------------------|-------------------------|---|
| CSIM1      | CSIE<br>1  | DIR   | ATE   | 0           | 0           | 0                   | CSIM<br>11  | CSIM<br>10                    | FF68H   | 00H                              | R/W                     |   |
| CSIM<br>11 |            | CSIM<br>10  | Selects clock of serial interface channel 1                                 |             |             |                     |             |                               |   |                                  |                         |   |
| 0          |            | ×   | Clock externally input to $\overline{\text{SCK1}}$ pin <sup>Note 1</sup>    |             |             |                     |             |                               |   |                                  |                         |   |
| 1          |            | 0   | Output of 8-bit timer register 2 (TM2)                                      |             |             |                     |             |                               |   |                                  |                         |   |
| 1          |            | 1   | Clock specified by bits 4 through 7 of timer clock select register 3 (TCL3) |             |             |                     |             |                               |   |                                  |                         |   |
| ATE        |            | Selects operation mode of serial interface channel 1              |   |             |             |                     |             |                               |   |                                  |                         |   |
| 0          |            | 3-wire serial I/O mode  |   |             |             |                     |             |                               |   |                                  |                         |   |
| 1          |            | 3-wire serial I/O mode with automatic transfer/reception function |   |             |             |                     |             |                               |   |                                  |                         |   |
| DIR        |            | First bit   |   |             |             | Function of SI1 pin |             |                               | Function of SO1 pin                           |                                  |                         |   |
| 0          |            | MSB   |   |             |             | SI1/P20             |             |                               | SO1   |                                  |                         |   |
| 1          |            | LSB   |   |             |             | (input)             |             |                               | (CMOS output)                                 |                                  |                         |   |
| CSIE<br>1  | CSIM<br>11 | PM20  | P20   | PM21        | P21         | PM22                | P22         | Operation of shift register 1 | Controls operation of counter of serial clock | Function of SI1/P20 pin          | Function of SO1/P21 pin | Function of $\overline{\text{SCK1}}$ /P22 |
| 0          | ×          | Note 2<br>×   | Note 2<br>×   | Note 2<br>× | Note 2<br>× | Note 2<br>×         | Note 2<br>× | Stops operation               | Clear   | P20<br>(CMOS I/O)                | P21<br>(CMOS I/O)       | P22<br>(CMOS I/O)                         |
| 1          | 0          | Note 3<br>1   | Note 3<br>×   | 0           | 0           | 1                   | ×           | Enables operation             | Count operation                               | SI1 <sup>Note 3</sup><br>(input) | SO1<br>(CMOS output)    | $\overline{\text{SCK1}}$<br>(input)       |
|            | 1          |   |   |             |             | 0                   | 1           |                               |   |                                  |                         | $\overline{\text{SCK1}}$<br>(CMOS output) |

- Notes**
1. Clear bit 2 (STRB) and bit 1 (BUSY1) of the automatic data transfer/reception control register (ADTC) to 0, 0 when the external clock input is selected by clearing CSIM11 to 0.
  2. These pins can be used as port pins.
  3. When only transmit is executed, this pin can be used as P20 (CMOS I/O). (Set bit 7 (RE) of the automatic data transfer/reception control register (ADTC) to 0.)

**Remark** × : don't care  
 PMxx: Port mode register  
 Pxx : Output latch of port

**Figure 8-14. Format of Automatic Data Transfer/Reception Control Register**  
 (μPD78054, 78054Y, 78078, 78078Y, 78098, 780018, 780018Y, 78058F, 78058FY,  
 78075B, 78075BY, 78098B subseries, μPD78070A, 78070AY)



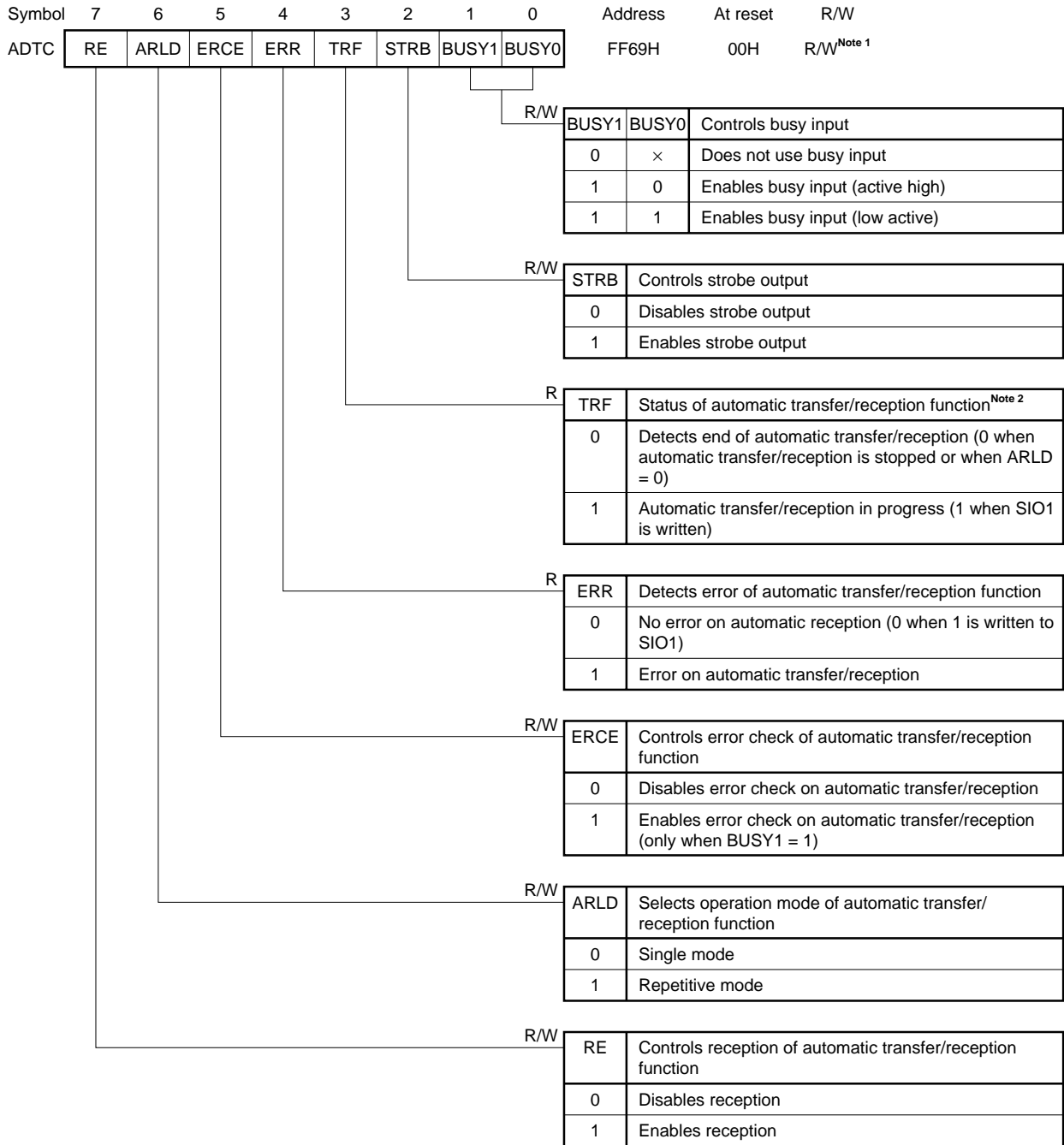
- Notes**
- Bits 3 and 4 (TRF and ERR) are read-only bits.
  - Identify the end of automatic transfer/reception by using TRF instead of CSIF1. (interrupt request flag)

**Caution** When external clock input is selected by clearing bit 1 (CSIM11) of the serial operating mode register 1 (CSIM1) to 0, clear STRB and BUSY1 of ADTC to 0, 0.

**Remark** ×: don't care

★

**Figure 8-15. Format of Automatic Data Transfer/Reception Control Register**  
( $\mu$ PD780058, 780058Y subseries)



**Notes 1.** Bits 3 and 4 (TRF and ERR) are read-only bits.

**2.** Identify the end of automatic transfer/reception by using TRF instead of CSIF1. (interrupt request flag)

**Cautions 1.** When external clock input is selected by clearing bit 1 (CSIM11) of the serial operating mode register 1 (CSIM1) to 0, clear STRB and BUSY1 of ADTC to 0, 0.

**2.** When using the P23/STB/TxD1 and P24/BUSY/RxD1 pins in the asynchronous serial interface (UART) mode of serial interface channel 2, the busy control option and busy & strobe control option are invalid.

**Remark** ×: don't care

**Figure 8-16. Format of Automatic Data Transfer/Reception Interval Specification Register**  
 (μPD78054, 78054Y, 78078, 78078Y, 780018, 780018Y, 780058, 780058Y, 78058F,  
 78058FY, 78075B, 78075BY subseries, μPD78070A, 78070AY) (1/4)

|        |       |   |   |       |       |       |       |       |         |          |     |
|--------|-------|---|---|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6 | 5 | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| ADTI   | ADTI7 | 0 | 0 | ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | FF6BH   | 00H      | R/W |

|       |  |
|-------|--|
| ADTI7 | Controls interval time of data transfer                  |
| 0     | Does not control interval time by ADTI <sup>Note 1</sup> |
| 1     | Controls interval time by ADTI (ADTI0 through ADTI4)     |

| ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | Specifies interval time of data transfer (f <sub>xx</sub> = 5.0 MHz) |                                 |
|-------|-------|-------|-------|-------|--|---------------------------------|
|       |       |       |       |       | Minimum value <sup>Note 2</sup>                                      | Maximum value <sup>Note 2</sup> |
| 0     | 0     | 0     | 0     | 0     | 18.4 μs + 0.5/f <sub>sck</sub>                                       | 20.0 μs + 1.5/f <sub>sck</sub>  |
| 0     | 0     | 0     | 0     | 1     | 31.2 μs + 0.5/f <sub>sck</sub>                                       | 32.8 μs + 1.5/f <sub>sck</sub>  |
| 0     | 0     | 0     | 1     | 0     | 44.0 μs + 0.5/f <sub>sck</sub>                                       | 45.6 μs + 1.5/f <sub>sck</sub>  |
| 0     | 0     | 0     | 1     | 1     | 56.8 μs + 0.5/f <sub>sck</sub>                                       | 58.4 μs + 1.5/f <sub>sck</sub>  |
| 0     | 0     | 1     | 0     | 0     | 69.6 μs + 0.5/f <sub>sck</sub>                                       | 71.2 μs + 1.5/f <sub>sck</sub>  |
| 0     | 0     | 1     | 0     | 1     | 82.4 μs + 0.5/f <sub>sck</sub>                                       | 84.0 μs + 1.5/f <sub>sck</sub>  |
| 0     | 0     | 1     | 1     | 0     | 95.2 μs + 0.5/f <sub>sck</sub>                                       | 96.8 μs + 1.5/f <sub>sck</sub>  |
| 0     | 0     | 1     | 1     | 1     | 108.0 μs + 0.5/f <sub>sck</sub>                                      | 109.6 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 0     | 0     | 0     | 120.8 μs + 0.5/f <sub>sck</sub>                                      | 122.4 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 0     | 0     | 1     | 133.6 μs + 0.5/f <sub>sck</sub>                                      | 135.2 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 0     | 1     | 0     | 146.4 μs + 0.5/f <sub>sck</sub>                                      | 148.0 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 0     | 1     | 1     | 159.2 μs + 0.5/f <sub>sck</sub>                                      | 160.8 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 1     | 0     | 0     | 172.0 μs + 0.5/f <sub>sck</sub>                                      | 173.6 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 1     | 0     | 1     | 184.8 μs + 0.5/f <sub>sck</sub>                                      | 186.4 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 1     | 1     | 0     | 197.6 μs + 0.5/f <sub>sck</sub>                                      | 199.2 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 1     | 1     | 1     | 210.4 μs + 0.5/f <sub>sck</sub>                                      | 212.0 μs + 1.5/f <sub>sck</sub> |

- Notes 1.** The interval time is dependent on only the CPU processing.
- 2.** The interval time of data transfer includes an error. The minimum and maximum values of the interval time for data transfer can be calculated by the following expressions (where n is the value set to ADTI0 through ADTI4). However, if the minimum value calculated by the expression below is less than 2/f<sub>sck</sub>, the minimum interval time is 2/f<sub>sck</sub>.

$$\text{Minimum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{28}{f_{xx}} + \frac{0.5}{f_{sck}}$$

$$\text{Maximum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{36}{f_{xx}} + \frac{1.5}{f_{sck}}$$

**Cautions** 1. Do not write ADTI during automatic transmission/reception operation.

2. Be sure to clear bits 5 and 6 to 0.

★

3. When controlling interval time of data transfer by automatic transfer/reception using ADTI, the busy control option is invalid.

**Remarks** 1.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )

2.  $f_x$  : main system clock oscillation frequency

3.  $f_{sck}$ : serial clock frequency

**Figure 8-16. Format of Automatic Data Transfer/Reception Interval Specification Register**  
 (μPD78054, 78054Y, 78078, 78078Y, 780018, 780018Y, 780058, 780058Y, 78058F,  
 78058FY, 78075B, 78075BY subseries, μPD78070A, 78070AY) (2/4)

|        |       |   |   |       |       |       |       |       |         |          |     |
|--------|-------|---|---|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6 | 5 | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| ADTI   | ADTI7 | 0 | 0 | ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | FF6BH   | 00H      | R/W |

| ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | Specifies interval time of data transfer (f <sub>xx</sub> = 5.0 MHz) |                                 |
|-------|-------|-------|-------|-------|--|---------------------------------|
|       |       |       |       |       | Minimum value <sup>Note</sup>  | Maximum value <sup>Note</sup>   |
| 1     | 0     | 0     | 0     | 0     | 223.2 μs + 0.5/f <sub>sck</sub>                                      | 224.8 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 0     | 0     | 1     | 236.0 μs + 0.5/f <sub>sck</sub>                                      | 237.6 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 0     | 1     | 0     | 248.8 μs + 0.5/f <sub>sck</sub>                                      | 250.4 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 0     | 1     | 1     | 261.6 μs + 0.5/f <sub>sck</sub>                                      | 263.2 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 1     | 0     | 0     | 274.4 μs + 0.5/f <sub>sck</sub>                                      | 276.0 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 1     | 0     | 1     | 287.2 μs + 0.5/f <sub>sck</sub>                                      | 288.8 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 1     | 1     | 0     | 300.0 μs + 0.5/f <sub>sck</sub>                                      | 301.6 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 1     | 1     | 1     | 312.8 μs + 0.5/f <sub>sck</sub>                                      | 314.4 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 0     | 0     | 0     | 325.6 μs + 0.5/f <sub>sck</sub>                                      | 327.2 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 0     | 0     | 1     | 338.4 μs + 0.5/f <sub>sck</sub>                                      | 340.0 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 0     | 1     | 0     | 351.2 μs + 0.5/f <sub>sck</sub>                                      | 352.8 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 0     | 1     | 1     | 364.0 μs + 0.5/f <sub>sck</sub>                                      | 365.6 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 1     | 0     | 0     | 376.8 μs + 0.5/f <sub>sck</sub>                                      | 378.4 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 1     | 0     | 1     | 389.6 μs + 0.5/f <sub>sck</sub>                                      | 391.2 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 1     | 1     | 0     | 402.4 μs + 0.5/f <sub>sck</sub>                                      | 404.0 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 1     | 1     | 1     | 415.2 μs + 0.5/f <sub>sck</sub>                                      | 416.8 μs + 1.5/f <sub>sck</sub> |

**Note** The interval time of data transfer includes an error margin. The minimum and maximum values of the interval time for data transfer can be calculated by the following expressions (where n is the value set to ADTI0 through ADTI4). However, if the minimum value calculated by the expression below is less than 2/f<sub>sck</sub>, the minimum interval time is 2/f<sub>sck</sub>.

$$\text{Minimum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{28}{f_{xx}} + \frac{0.5}{f_{sck}}$$

$$\text{Maximum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{36}{f_{xx}} + \frac{1.5}{f_{sck}}$$

**Cautions 1.** Do not write ADTI during automatic transfer/reception operation.

**2.** Be sure to clear bits 5 and 6 to 0.

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**3.** When controlling interval time of data transfer by automatic transfer/reception using ADTI, the busy control option is invalid.

**Remarks 1.** f<sub>xx</sub> : main system clock frequency (f<sub>x</sub> or f<sub>x</sub>/2)

**2.** f<sub>x</sub> : main system clock oscillation frequency

**3.** f<sub>sck</sub>: serial clock frequency

**Figure 8-16. Format of Automatic Data Transfer/Reception Interval Specification Register**  
 (μPD78054, 78054Y, 78078, 78078Y, 780018, 780018Y, 780058, 780058Y, 78058F,  
 78058FY, 78075B, 78075BY subseries, μPD78070A, 78070AY) (3/4)

|        |       |   |   |       |       |       |       |       |         |          |     |
|--------|-------|---|---|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6 | 5 | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| ADTI   | ADTI7 | 0 | 0 | ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | FF6BH   | 00H      | R/W |

|       |  |
|-------|--|
| ADTI7 | Controls interval time of data transfer                  |
| 0     | Does not control interval time by ADTI <sup>Note 1</sup> |
| 1     | Controls interval time by ADTI (ADTI0 through ADTI4)     |

| ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | Specifies interval time of data transfer (f <sub>xx</sub> = 2.5 MHz) |                                 |
|-------|-------|-------|-------|-------|--|---------------------------------|
|       |       |       |       |       | Minimum value <sup>Note 2</sup>                                      | Maximum value <sup>Note 2</sup> |
| 0     | 0     | 0     | 0     | 0     | 36.8 μs + 0.5/f <sub>sck</sub>                                       | 40.0 μs + 1.5/f <sub>sck</sub>  |
| 0     | 0     | 0     | 0     | 1     | 62.4 μs + 0.5/f <sub>sck</sub>                                       | 65.6 μs + 1.5/f <sub>sck</sub>  |
| 0     | 0     | 0     | 1     | 0     | 88.0 μs + 0.5/f <sub>sck</sub>                                       | 91.2 μs + 1.5/f <sub>sck</sub>  |
| 0     | 0     | 0     | 1     | 1     | 113.6 μs + 0.5/f <sub>sck</sub>                                      | 116.8 μs + 1.5/f <sub>sck</sub> |
| 0     | 0     | 1     | 0     | 0     | 139.2 μs + 0.5/f <sub>sck</sub>                                      | 142.4 μs + 1.5/f <sub>sck</sub> |
| 0     | 0     | 1     | 0     | 1     | 164.8 μs + 0.5/f <sub>sck</sub>                                      | 168.0 μs + 1.5/f <sub>sck</sub> |
| 0     | 0     | 1     | 1     | 0     | 190.4 μs + 0.5/f <sub>sck</sub>                                      | 193.6 μs + 1.5/f <sub>sck</sub> |
| 0     | 0     | 1     | 1     | 1     | 216.0 μs + 0.5/f <sub>sck</sub>                                      | 219.2 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 0     | 0     | 0     | 241.6 μs + 0.5/f <sub>sck</sub>                                      | 244.8 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 0     | 0     | 1     | 267.2 μs + 0.5/f <sub>sck</sub>                                      | 270.4 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 0     | 1     | 0     | 292.8 μs + 0.5/f <sub>sck</sub>                                      | 296.0 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 0     | 1     | 1     | 318.4 μs + 0.5/f <sub>sck</sub>                                      | 321.6 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 1     | 0     | 0     | 344.0 μs + 0.5/f <sub>sck</sub>                                      | 347.2 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 1     | 0     | 1     | 369.6 μs + 0.5/f <sub>sck</sub>                                      | 372.8 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 1     | 1     | 0     | 395.2 μs + 0.5/f <sub>sck</sub>                                      | 398.4 μs + 1.5/f <sub>sck</sub> |
| 0     | 1     | 1     | 1     | 1     | 420.8 μs + 0.5/f <sub>sck</sub>                                      | 424.0 μs + 1.5/f <sub>sck</sub> |

- Notes 1.** The interval time is dependent on only the CPU processing.
- 2.** The interval time of data transfer includes an error margin. The minimum and maximum values of the interval time for data transfer can be calculated by the following expressions (where n is the value set to ADTI0 through ADTI4). However, if the minimum value calculated by the expression below is less than 2/f<sub>sck</sub>, the minimum interval time is 2/f<sub>sck</sub>.

$$\text{Minimum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{28}{f_{xx}} + \frac{0.5}{f_{sck}}$$

$$\text{Maximum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{36}{f_{xx}} + \frac{1.5}{f_{sck}}$$

**Cautions** 1. Do not write ADTI during automatic transfer/reception operation.

2. Be sure to clear bits 5 and 6 to 0.

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3. When controlling interval time of data transfer by automatic transfer/reception using ADTI, the busy control option is invalid.

**Remarks** 1.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )

2.  $f_x$  : main system clock oscillation frequency

3.  $f_{sck}$ : serial clock frequency



**Figure 8-16. Format of Automatic Data Transfer/Reception Interval Specification Register**  
 (μPD78054, 78054Y, 78078, 78078Y, 780018, 780018Y, 780058, 780058Y, 78058F,  
 78058FY, 78075B, 78075BY subseries, μPD78070A, 78070AY) (4/4)

|        |       |   |   |       |       |       |       |       |         |          |     |
|--------|-------|---|---|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6 | 5 | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| ADTI   | ADTI7 | 0 | 0 | ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | FF6BH   | 00H      | R/W |

| ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | Specifies interval time of data transfer (f <sub>xx</sub> = 2.5 MHz) |                                 |
|-------|-------|-------|-------|-------|--|---------------------------------|
|       |       |       |       |       | Minimum value <sup>Note</sup>  | Maximum value <sup>Note</sup>   |
| 1     | 0     | 0     | 0     | 0     | 446.4 μs + 0.5/f <sub>sck</sub>                                      | 449.6 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 0     | 0     | 1     | 472.0 μs + 0.5/f <sub>sck</sub>                                      | 475.2 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 0     | 1     | 0     | 497.6 μs + 0.5/f <sub>sck</sub>                                      | 500.8 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 0     | 1     | 1     | 523.2 μs + 0.5/f <sub>sck</sub>                                      | 526.4 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 1     | 0     | 0     | 548.8 μs + 0.5/f <sub>sck</sub>                                      | 552.0 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 1     | 0     | 1     | 574.4 μs + 0.5/f <sub>sck</sub>                                      | 577.6 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 1     | 1     | 0     | 600.0 μs + 0.5/f <sub>sck</sub>                                      | 603.2 μs + 1.5/f <sub>sck</sub> |
| 1     | 0     | 1     | 1     | 1     | 625.6 μs + 0.5/f <sub>sck</sub>                                      | 628.8 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 0     | 0     | 0     | 651.2 μs + 0.5/f <sub>sck</sub>                                      | 654.4 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 0     | 0     | 1     | 676.8 μs + 0.5/f <sub>sck</sub>                                      | 680.0 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 0     | 1     | 0     | 702.4 μs + 0.5/f <sub>sck</sub>                                      | 705.6 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 0     | 1     | 1     | 728.0 μs + 0.5/f <sub>sck</sub>                                      | 731.2 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 1     | 0     | 0     | 753.6 μs + 0.5/f <sub>sck</sub>                                      | 756.8 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 1     | 0     | 1     | 779.2 μs + 0.5/f <sub>sck</sub>                                      | 782.4 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 1     | 1     | 0     | 804.8 μs + 0.5/f <sub>sck</sub>                                      | 808.0 μs + 1.5/f <sub>sck</sub> |
| 1     | 1     | 1     | 1     | 1     | 830.4 μs + 0.5/f <sub>sck</sub>                                      | 833.6 μs + 1.5/f <sub>sck</sub> |

**Note** The interval time of data transfer includes an error margin. The minimum and maximum values of the interval time for data transfer can be calculated by the following expressions (where n is the value set to ADTI0 through ADTI4). However, if the minimum value calculated by the expression below is less than 2/f<sub>sck</sub>, the minimum interval time is 2/f<sub>sck</sub>.

$$\text{Minimum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{28}{f_{xx}} + \frac{0.5}{f_{sck}}$$

$$\text{Maximum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{36}{f_{xx}} + \frac{1.5}{f_{sck}}$$

- Cautions**
1. Do not write ADTI during automatic transfer/reception operation.
  2. Be sure to clear bits 5 and 6 to 0.
  3. When controlling interval time of data transfer by automatic transfer/reception using ADTI, the busy control option is invalid.

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- Remarks**
1. f<sub>xx</sub> : main system clock frequency (f<sub>x</sub> or f<sub>x</sub>/2)
  2. f<sub>x</sub> : main system clock oscillation frequency
  3. f<sub>sck</sub>: serial clock frequency

**Figure 8-17. Format of Automatic Data Transfer/Reception Interval Specification Register ( $\mu$ PD78098, 78098B subseries) (1/2)**

|        |       |   |   |       |       |       |       |       |         |          |     |
|--------|-------|---|---|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6 | 5 | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| ADTI   | ADTI7 | 0 | 0 | ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | FF6BH   | 00H      | R/W |

|       |  |
|-------|--|
| ADTI7 | Controls interval time of data transfer                  |
| 0     | Does not control interval time by ADTI <sup>Note 1</sup> |
| 1     | Controls interval time by ADTI (ADTI0 through ADTI4)     |

| ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | Specifies interval time of data transfer ( $f_{xx} = 4.0 \text{ MHz}$ ) |  |
|-------|-------|-------|-------|-------|---|--|
|       |       |       |       |       | Minimum value <sup>Note 2</sup>   | Maximum value <sup>Note 2</sup>          |
| 0     | 0     | 0     | 0     | 0     | $23.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                 | $25.0 \mu\text{s} + 1.5/f_{\text{SCK}}$  |
| 0     | 0     | 0     | 0     | 1     | $39.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                 | $41.0 \mu\text{s} + 1.5/f_{\text{SCK}}$  |
| 0     | 0     | 0     | 1     | 0     | $55.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                 | $57.0 \mu\text{s} + 1.5/f_{\text{SCK}}$  |
| 0     | 0     | 0     | 1     | 1     | $71.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                 | $73.0 \mu\text{s} + 1.5/f_{\text{SCK}}$  |
| 0     | 0     | 1     | 0     | 0     | $87.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                 | $89.0 \mu\text{s} + 1.5/f_{\text{SCK}}$  |
| 0     | 0     | 1     | 0     | 1     | $103.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $105.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 0     | 0     | 1     | 1     | 0     | $119.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $121.6 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 0     | 0     | 1     | 1     | 1     | $135.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $137.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 0     | 1     | 0     | 0     | 0     | $151.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $153.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 0     | 1     | 0     | 0     | 1     | $167.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $169.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 0     | 1     | 0     | 1     | 0     | $183.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $185.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 0     | 1     | 0     | 1     | 1     | $199.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $201.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 0     | 1     | 1     | 0     | 0     | $215.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $217.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 0     | 1     | 1     | 0     | 1     | $231.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $233.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 0     | 1     | 1     | 1     | 0     | $247.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $249.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 0     | 1     | 1     | 1     | 1     | $263.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $265.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |

- Notes 1.** The interval time is dependent on only the CPU processing.
- 2.** The interval time of data transfer includes an error margin. The minimum and maximum values of the interval time for data transfer can be calculated by the following expressions (where n is the value set to ADTI0 through ADTI4). However, if the minimum value calculated by the expression below is less than  $2/f_{\text{SCK}}$ , the minimum interval time is  $2/f_{\text{SCK}}$ .

$$\text{Minimum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{28}{f_{xx}} + \frac{0.5}{f_{\text{SCK}}}$$

$$\text{Maximum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{36}{f_{xx}} + \frac{1.5}{f_{\text{SCK}}}$$

**Cautions** 1. Do not write ADTI during automatic transfer/reception operation.

2. Be sure to clear bits 5 and 6 to 0.

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3. When controlling interval time of data transfer by automatic transfer/reception using ADTI, the busy control option is invalid.

**Remarks** 1.  $f_{xx}$  : main system clock frequency

2.  $f_{sck}$ : serial clock frequency

**Figure 8-17. Format of Automatic Data Transfer/Reception Interval Specification Register ( $\mu$ PD78098, 78098B subseries) (2/2)**

|        |       |   |   |       |       |       |       |       |         |          |     |
|--------|-------|---|---|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6 | 5 | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| ADTI   | ADTI7 | 0 | 0 | ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | FF6BH   | 00H      | R/W |

| ADTI4 | ADTI3 | ADTI2 | ADTI1 | ADTI0 | Specifies interval time of data transfer ( $f_{xx} = 4.0 \text{ MHz}$ ) |  |
|-------|-------|-------|-------|-------|---|--|
|       |       |       |       |       | Minimum value <sup>Note</sup>   | Maximum value <sup>Note</sup>            |
| 1     | 0     | 0     | 0     | 0     | $279.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $281.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 0     | 0     | 0     | 1     | $295.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $297.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 0     | 0     | 1     | 0     | $311.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $313.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 0     | 0     | 1     | 1     | $327.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $329.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 0     | 1     | 0     | 0     | $343.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $345.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 0     | 1     | 0     | 1     | $359.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $361.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 0     | 1     | 1     | 0     | $375.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $377.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 0     | 1     | 1     | 1     | $391.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $393.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 1     | 0     | 0     | 0     | $407.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $409.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 1     | 0     | 0     | 1     | $423.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $425.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 1     | 0     | 1     | 0     | $439.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $441.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 1     | 0     | 1     | 1     | $455.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $457.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 1     | 1     | 0     | 0     | $471.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $473.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 1     | 1     | 0     | 1     | $487.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $489.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 1     | 1     | 1     | 0     | $503.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $505.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |
| 1     | 1     | 1     | 1     | 1     | $519.0 \mu\text{s} + 0.5/f_{\text{SCK}}$                                | $521.0 \mu\text{s} + 1.5/f_{\text{SCK}}$ |

**Note** The interval time of data transfer includes an error margin. The minimum and maximum values of the interval time for data transfer can be calculated by the following expressions (where n is the value set to ADTI0 through ADTI4). However, if the minimum value calculated by the expression below is less than  $2/f_{\text{SCK}}$ , the minimum interval time is  $2/f_{\text{SCK}}$ .

$$\text{Minimum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{28}{f_{xx}} + \frac{0.5}{f_{\text{SCK}}}$$

$$\text{Maximum value} = (n+1) \times \frac{2^6}{f_{xx}} + \frac{36}{f_{xx}} + \frac{1.5}{f_{\text{SCK}}}$$

**Cautions 1. Do not write ADTI during automatic transfer/reception operation.**

**2. Be sure to clear bits 5 and 6 to 0.**

★

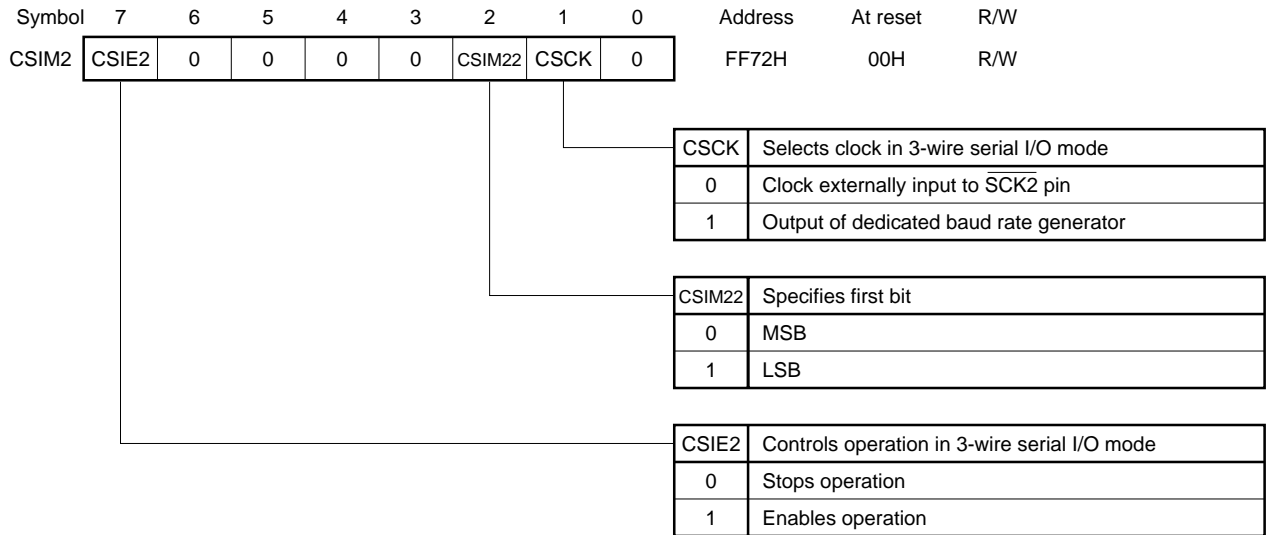
**3. When controlling interval time of data transfer by automatic transfer/reception using ADTI, the busy control option is invalid.**

**Remarks 1.**  $f_{xx}$  : main system clock frequency

**2.**  $f_{\text{SCK}}$ : serial clock frequency

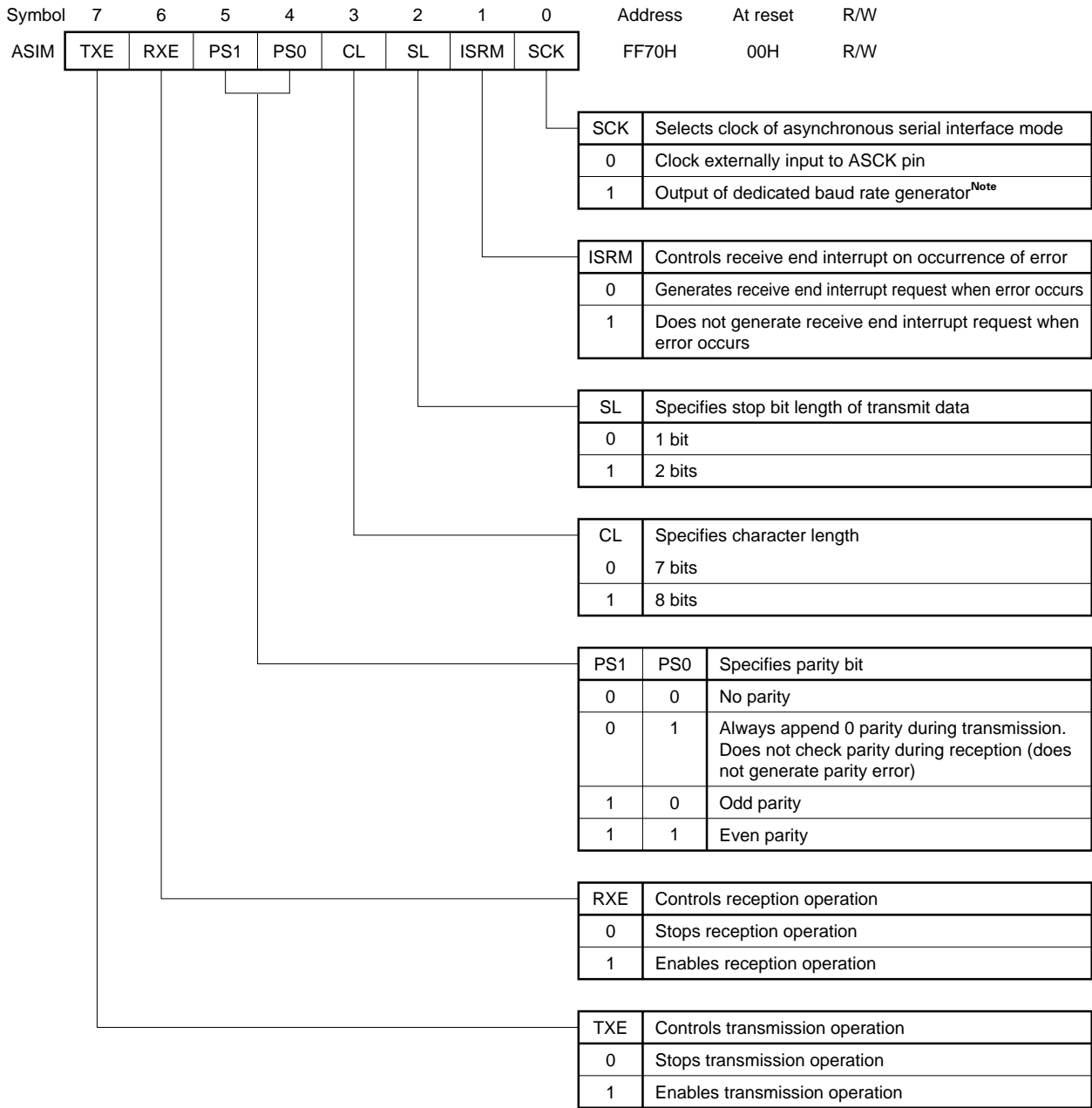
**Figure 8-18. Format of Serial Operating Mode Register 2**

( $\mu$ PD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 78083, 78098, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY, 78098B subseries,  $\mu$ PD78070A, 78070AY)



- Cautions**
1. Be sure to clear bits 0 and 3 through 6 to 0.
  2. Set CSIM2 to 00H in the UART mode.

**Figure 8-19. Format of Asynchronous Serial Interface Mode Register**  
 (μPD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 78083, 78098, 78098, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY, 78098B subseries, μPD78070A, 78070AY)



**Note** When the baud rate generator output is selected by setting SCK to 1, the ASCK pin can be used as an I/O port pin.

- Cautions**
1. Set ASIM to 00H when the 3-wire serial I/O mode is selected.
  2. Before changing the operation mode, stop the serial transfer/reception operation.

**Table 8-4. Setting of Operation Modes of Serial Interface Channel 2**  
 (μPD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 78083, 78098, 78058F, 78058FY,  
 78064B, 78075B, 78075BY, 78098B subseries, μPD78070A, 78070AY)

**(1) Operation stop mode**

| ASIM   |     |     | CSIM2 |        |      | PM70                | P70                 | PM71                | P71                 | PM72                | P72                 | First bit          | Shift clock | Function of P70/SI2/RxD pin | Function of P71/SO2/TxD pin | Function of P72/SCK2/ASCK pin |
|--------|-----|-----|-------|--------|------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|--------------------|-------------|-----------------------------|-----------------------------|-------------------------------|
| TXE    | RXE | SCK | CSIE2 | CSIM22 | CSCK |                     |                     |                     |                     |                     |                     |                    |             |                             |                             |                               |
| 0      | 0   | ×   | 0     | ×      | ×    | × <sup>Note 1</sup> | × <sup>Note 1</sup> | × <sup>Note 1</sup> | × <sup>Note 1</sup> | × <sup>Note 1</sup> | × <sup>Note 1</sup> | –                  | –           | P70                         | P71                         | P72                           |
| Others |     |     |       |        |      |                     |                     |                     |                     |                     |                     | Setting prohibited |             |                             |                             |                               |

**(2) 3-wire serial I/O mode**

| ASIM   |     |     | CSIM2 |        |      | PM70                | P70                 | PM71 | P71 | PM72 | P72            | First bit          | Shift clock           | Function of P70/SI2/RxD pin | Function of P71/SO2/TxD pin | Function of P72/SCK2/ASCK pin |            |
|--------|-----|-----|-------|--------|------|---------------------|---------------------|------|-----|------|----------------|--------------------|-----------------------|-----------------------------|-----------------------------|-------------------------------|------------|
| TXE    | RXE | SCK | CSIE2 | CSIM22 | CSCK |                     |                     |      |     |      |                |                    |                       |                             |                             |                               |            |
| 0      | 0   | 0   | 1     | 0      | 0    | 1 <sup>Note 2</sup> | × <sup>Note 2</sup> | 0    | 1   | 1    | ×              | MSB                | External clock        | SI2 <sup>Note 2</sup>       | SO2 (CMOS output)           | SCK2 input                    |            |
|        |     |     |       |        | 0    |                     |                     |      |     | 1    | Internal clock |                    | SCK2 output           |                             |                             |                               |            |
|        |     |     |       |        | 1    |                     |                     |      |     | 0    | LSB            | External clock     | SI2 <sup>Note 2</sup> |                             |                             | SO2 (CMOS output)             | SCK2 input |
|        |     |     |       |        | 1    |                     |                     |      |     | 1    |                | Internal clock     |                       |                             |                             |                               |            |
| Others |     |     |       |        |      |                     |                     |      |     |      |                | Setting prohibited |                       |                             |                             |                               |            |

**(3) Asynchronous serial interface mode**

| ASIM   |     |     | CSIM2 |        |      | PM70                | P70                 | PM71                | P71                 | PM72 | P72            | First bit          | Shift clock    | Function of P70/SI2/RxD pin | Function of P71/SO2/TxD pin | Function of P72/SCK2/ASCK pin |
|--------|-----|-----|-------|--------|------|---------------------|---------------------|---------------------|---------------------|------|----------------|--------------------|----------------|-----------------------------|-----------------------------|-------------------------------|
| TXE    | RXE | SCK | CSIE2 | CSIM22 | CSCK |                     |                     |                     |                     |      |                |                    |                |                             |                             |                               |
| 1      | 0   | 0   | 0     | 0      | 0    | × <sup>Note 1</sup> | × <sup>Note 1</sup> | 0                   | 1                   | 1    | ×              | LSB                | External clock | P70                         | TxD (CMOS output)           | ASCK input                    |
|        |     | 1   |       |        |      |                     |                     |                     |                     | ×    | Internal clock |                    | P72            |                             |                             |                               |
| 0      | 1   | 0   | 0     | 0      | 0    | 1                   | ×                   | × <sup>Note 1</sup> | × <sup>Note 1</sup> | 1    | ×              |                    | External clock | RxD                         | P71                         | ASCK input                    |
|        |     | 1   |       |        |      |                     |                     |                     |                     | ×    | Internal clock |                    | P72            |                             |                             |                               |
| 1      | 1   | 0   | 0     | 0      | 0    | 1                   | ×                   | 0                   | 1                   | 1    | ×              |                    | External clock |                             | TxD (CMOS output)           | ASCK input                    |
|        |     | 1   |       |        |      |                     |                     |                     |                     | ×    | Internal clock |                    | P72            |                             |                             |                               |
| Others |     |     |       |        |      |                     |                     |                     |                     |      |                | Setting prohibited |                |                             |                             |                               |

**Notes 1.** These pins can be used as port pins.

**2.** This pin can be used as P70 (CMOS I/O) when only transmission is executed.

**Remark** × : don't care

PM<sub>xx</sub>: port mode register

P<sub>xx</sub> : output latch of port

★ Table 8-5. Setting of Operation Modes of Serial Interface Channel 2 ( $\mu$ PD780058 and 780058Y Subseries) (1/2)

## (1) Operation stop mode

| ASIM   |     |     | CSIM2 |        |      | SIPS   |        | PM70            | P70             | PM71            | P71             | PM23            | P23             | PM24            | P24             | PM72            | P72             | First bit          | Shift clock | Function of P70/SI2/RxD0 pin | Function of P71/SO2/TxD0 pin | Function of P23/STB/TxD1 pin | Function of P24/BUSY/RxD1 pin | Function of P72/ $\overline{\text{SCK2}}$ /ASCK pin |
|--------|-----|-----|-------|--------|------|--------|--------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|--------------------|-------------|------------------------------|------------------------------|------------------------------|-------------------------------|---|
| TXE    | RXE | SCK | CSIE2 | CSIM22 | CSCK | SIPS21 | SIPS20 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                    |             |                              |                              |                              |                               |   |
| 0      | 0   | ×   | 0     | ×      | ×    | ×      | ×      | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | –                  | –           | P70                          | P71                          | P23/STB                      | P24/BUSY                      | P72   |
| Others |     |     |       |        |      |        |        |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 | Setting prohibited |             |                              |                              |                              |                               |   |

## (2) 3-wire serial I/O mode

| ASIM   |     |     | CSIM2 |        |      | SIPS   |        | PM70            | P70             | PM71 | P71 | PM23            | P23             | PM24            | P24             | PM72 | P72            | First bit          | Shift clock                     | Function of P70/SI2/RxD0 pin | Function of P71/SO2/TxD0 pin | Function of P23/STB/TxD1 pin | Function of P24/BUSY/RxD1 pin | Function of P72/ $\overline{\text{SCK2}}$ /ASCK pin |
|--------|-----|-----|-------|--------|------|--------|--------|-----------------|-----------------|------|-----|-----------------|-----------------|-----------------|-----------------|------|----------------|--------------------|---------------------------------|------------------------------|------------------------------|------------------------------|-------------------------------|---|
| TXE    | RXE | SCK | CSIE2 | CSIM22 | CSCK | SIPS21 | SIPS20 |                 |                 |      |     |                 |                 |                 |                 |      |                |                    |                                 |                              |                              |                              |                               |   |
| 0      | 0   | 0   | 1     | 0      | 0    | ×      | ×      | $\times$ Note 2 | $\times$ Note 2 | 0    | 1   | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | 1    | ×              | MSB                | External clock                  | SI2>Note 2                   | SO2<br>(CMOS output)         | P23/STB                      | P24/BUSY                      | $\overline{\text{SCK2}}$ input                      |
|        |     |     |       |        | 1    |        |        |                 |                 |      |     |                 |                 |                 | 0               | 1    | Internal clock |                    | $\overline{\text{SCK2}}$ output |                              |                              |                              |                               |   |
|        |     |     | 1     | 1      | 0    |        |        |                 |                 |      |     |                 |                 |                 |                 |      |                | LSB                | External clock                  | SI2>Note 2                   | SO2<br>(CMOS output)         |                              |                               | $\overline{\text{SCK2}}$ input                      |
|        |     |     |       |        | 1    |        |        |                 |                 |      |     |                 |                 |                 | 0               | 1    | Internal clock |                    | $\overline{\text{SCK2}}$ output |                              |                              |                              |                               |   |
| Others |     |     |       |        |      |        |        |                 |                 |      |     |                 |                 |                 |                 |      |                | Setting prohibited |                                 |                              |                              |                              |                               |   |

**Notes 1.** These pins can be used as port pins.

**2.** This pin can be used as P70 (CMOS I/O) when only transmission is executed.

**Remark** × : don't care

PM××: port mode register

P×× : output latch of port



**Table 8-5. Setting of Operation Modes of Serial Interface Channel 2 ( $\mu$ PD780058 and 780058Y Subseries) (2/2)**

**(3) Asynchronous serial interface mode**

| ASIM   |     |     | CSIM2 |        |      | SIPS   |        | PM70  | P70   | PM71  | P71   | PM23  | P23   | PM24  | P24   | PM72 | P72 | First bit          | Shift clock    | Function of P70/SI2/RxD0 pin | Function of P71/SO2/TxD0 pin | Function of P23/STB/TxD1 pin | Function of P24/BUSY/RxD1 pin | Function of P72/ $\overline{\text{SCK2}}$ /ASCK pin |
|--------|-----|-----|-------|--------|------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|------|-----|--------------------|----------------|------------------------------|------------------------------|------------------------------|-------------------------------|---|
| TXE    | RXE | SCK | CSIE2 | CSIM22 | CSCK | SIPS21 | SIPS20 |       |       |       |       |       |       |       |       |      |     |                    |                |                              |                              |                              |                               |   |
| 1      | 0   | 0   | 0     | 0      | 0    | 0      | 0      | xNote | xNote | 0     | 1     | xNote | xNote | xNote | xNote | 1    | ×   | LSB                | External clock | P70                          | TxD0<br>(CMOS output)        | P23/STB                      | P24/BUSY                      | ASCK input  |
|        |     | 1   |       |        |      |        |        | xNote | xNote |       |       |       |       |       |       |      |     |                    |                |                              |                              |                              |                               |   |
| 0      | 1   | 0   | 0     | 0      | 0    | 0      | 0      | 1     | ×     | xNote | xNote | xNote | xNote | xNote | xNote | 1    | ×   |                    | External clock | RxD0                         | P71                          |                              |                               | ASCK input  |
|        |     | 1   |       |        |      |        |        | xNote | xNote |       |       |       |       |       |       |      |     |                    |                |                              |                              |                              |                               |   |
| 1      | 1   | 0   | 0     | 0      | 0    | 0      | 0      | 1     | ×     | 0     | 1     | xNote | xNote | xNote | xNote | 1    | ×   |                    | External clock |                              | TxD0<br>(CMOS output)        |                              |                               | ASCK input  |
|        |     | 1   |       |        |      |        |        | xNote | xNote |       |       |       |       |       |       |      |     |                    |                |                              |                              |                              |                               |   |
| 1      | 0   | 0   | 0     | 0      | 0    | 1      | 0      | xNote | xNote | 0     | 1     | 0     | 1     | xNote | xNote | 1    | ×   |                    | External clock | P70                          | Output high                  | TxD1                         | P24/BUSY                      | ASCK input  |
|        |     | 1   |       |        |      |        |        | xNote | xNote |       |       |       |       |       |       |      |     |                    |                |                              |                              |                              |                               |   |
| 0      | 1   | 0   | 0     | 0      | 0    | 0      | 1      | 1     | ×     | xNote | xNote | xNote | xNote | 1     | ×     | 1    | ×   |                    | External clock | P70                          | P71                          | P23/STB                      | RxD1                          | ASCK input  |
|        |     | 1   |       |        |      |        |        | xNote | xNote |       |       |       |       |       |       |      |     |                    |                |                              |                              |                              |                               |   |
| 1      | 1   | 0   | 0     | 0      | 0    | 1      | 1      | 1     | ×     | 0     | 1     | 0     | 1     | 1     | ×     | 1    | ×   |                    | External clock | P70                          | Output high                  | TxD1                         | RxD1                          | ASCK input  |
|        |     | 1   |       |        |      |        |        | xNote | xNote |       |       |       |       |       |       |      |     |                    |                |                              |                              |                              |                               |   |
| Others |     |     |       |        |      |        |        |       |       |       |       |       |       |       |       |      |     | Setting prohibited |                |                              |                              |                              |                               |   |

**Note** These pins can be used as port pins.

**Remark** × : don't care  
 PMxx: port mode register  
 Pxx : output latch of port

★ Table 8-6. Setting of Operation Modes of Serial Interface Channel 2 (μPD780308 and 780308Y Subseries) (1/2)

## (1) Operation stop mode

| ASIM   |     |     | CSIM2 |        |      | SIPS   |        | PM70            | P70             | PM71            | P71             | PM113           | P113            | PM114           | P114            | PM72            | P72             | First bit          | Shift clock | Function of P70/SI2/RxD0 pin | Function of P71/SO2/TxD0 pin | Function of P113/TxD pin | Function of P114/RxD pin | Function of P72/ $\overline{\text{SCK2}}$ /ASCK pin |
|--------|-----|-----|-------|--------|------|--------|--------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|--------------------|-------------|------------------------------|------------------------------|--------------------------|--------------------------|---|
| TXE    | RXE | SCK | CSIE2 | CSIM22 | CSCK | SIPS21 | SIPS20 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                    |             |                              |                              |                          |                          |   |
| 0      | 0   | ×   | 0     | ×      | ×    | ×      | ×      | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | –                  | –           | P70                          | P71                          | P113                     | P114                     | P72   |
| Others |     |     |       |        |      |        |        |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 | Setting prohibited |             |                              |                              |                          |                          |   |

## (2) 3-wire serial I/O mode

| ASIM   |     |     | CSIM2 |        |      | SIPS   |        | PM70            | P70             | PM71 | P71 | PM113           | P113            | PM114           | P114            | PM72 | P72 | First bit          | Shift clock    | Function of P70/SI2/RxD0 pin | Function of P71/SO2/TxD0 pin | Function of P113/TxD pin | Function of P114/RxD pin | Function of P72/ $\overline{\text{SCK2}}$ /ASCK pin |
|--------|-----|-----|-------|--------|------|--------|--------|-----------------|-----------------|------|-----|-----------------|-----------------|-----------------|-----------------|------|-----|--------------------|----------------|------------------------------|------------------------------|--------------------------|--------------------------|---|
| TXE    | RXE | SCK | CSIE2 | CSIM22 | CSCK | SIPS21 | SIPS20 |                 |                 |      |     |                 |                 |                 |                 |      |     |                    |                |                              |                              |                          |                          |   |
| 0      | 0   | 0   | 1     | 0      | 0    | ×      | ×      | $\times$ Note 2 | $\times$ Note 2 | 0    | 1   | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | $\times$ Note 1 | 1    | ×   | MSB                | External clock | $\text{SI2}$ Note 2          | SO2<br>(CMOS output)         | P113                     | P114                     | $\overline{\text{SCK2}}$ input                      |
|        |     |     |       |        |      |        |        |                 |                 |      |     |                 |                 |                 |                 | 0    | 1   |                    | Internal clock |                              |                              |                          |                          | $\overline{\text{SCK2}}$ output                     |
|        |     |     | 1     | 1      | 0    |        |        |                 |                 |      |     |                 |                 |                 |                 | 1    | ×   | LSB                | External clock | $\text{SI2}$ Note 2          | SO2<br>(CMOS output)         |                          |                          | $\overline{\text{SCK2}}$ input                      |
|        |     |     |       |        |      |        |        |                 |                 |      |     |                 |                 |                 |                 |      |     |                    | 0              |                              |                              |                          |                          | 1   |
| Others |     |     |       |        |      |        |        |                 |                 |      |     |                 |                 |                 |                 |      |     | Setting prohibited |                |                              |                              |                          |                          |   |

**Notes 1.** These pins can be used as port pins.

**2.** This pin can be used as P70 (CMOS I/O) when only transmission is executed.

**Remark** × : don't care

PM××: port mode register

P×× : output latch of port

**Table 8-6. Setting of Operation Modes of Serial Interface Channel 2 ( $\mu$ PD780308 and 780308Y Subseries) (2/2)**

**(3) Asynchronous serial interface mode**

| ASIM   |     |     | CSIM2 |        |      | SIPS   |        | PM70          | P70           | PM71          | P71           | PM113         | P113          | PM114         | P114          | PM72 | P72      | First bit          | Shift clock    | Function of P70/SI2/RxD0 pin | Function of P71/SO2/TxD0 pin | Function of P113/TxD pin | Function of P114/RxD pin | Function of P72/ $\overline{\text{SCK2}}$ /ASCK pin |
|--------|-----|-----|-------|--------|------|--------|--------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|------|----------|--------------------|----------------|------------------------------|------------------------------|--------------------------|--------------------------|---|
| TXE    | RXE | SCK | CSIE2 | CSIM22 | CSCK | SIPS21 | SIPS20 |               |               |               |               |               |               |               |               |      |          |                    |                |                              |                              |                          |                          |   |
| 1      | 0   | 0   | 0     | 0      | 0    | 0      | 0      | $\times$ Note | $\times$ Note | 0             | 1             | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | 1    | $\times$ | LSB                | External clock | P70                          | TxD                          | P113                     | P114                     | ASCK input  |
|        |     | 1   |       |        |      |        |        | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | P72           |      |          |                    |                |                              |                              |                          |                          |   |
| 0      | 1   | 0   | 0     | 0      | 0    | 0      | 0      | 1             | $\times$      | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | 1    | $\times$ | LSB                | External clock | RxD                          | P71                          | P113                     | P114                     | ASCK input  |
|        |     | 1   |       |        |      |        |        | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | P72           |      |          |                    |                |                              |                              |                          |                          |   |
| 1      | 1   | 0   | 0     | 0      | 0    | 0      | 0      | 1             | $\times$      | 0             | 1             | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | 1    | $\times$ | LSB                | External clock | TxD                          | P71                          | P113                     | P114                     | ASCK input  |
|        |     | 1   |       |        |      |        |        | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | P72           |      |          |                    |                |                              |                              |                          |                          |   |
| 1      | 0   | 0   | 0     | 0      | 0    | 1      | 0      | $\times$ Note | $\times$ Note | 0             | 1             | 0             | 1             | $\times$ Note | $\times$ Note | 1    | $\times$ | LSB                | External clock | P70                          | Output high                  | TxD                      | P114                     | ASCK input  |
|        |     | 1   |       |        |      |        |        | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | P72           |      |          |                    |                |                              |                              |                          |                          |   |
| 0      | 1   | 0   | 0     | 0      | 0    | 0      | 1      | 1             | $\times$      | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | 1             | $\times$      | 1    | $\times$ | LSB                | External clock | P70                          | P71                          | P113                     | RxD                      | ASCK input  |
|        |     | 1   |       |        |      |        |        | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | (input)       | P72  |          |                    |                |                              |                              |                          |                          |   |
| 1      | 1   | 0   | 0     | 0      | 0    | 1      | 1      | 1             | $\times$      | 0             | 1             | 0             | 1             | 1             | $\times$      | 1    | $\times$ | LSB                | External clock | P70                          | Output high                  | TxD                      | RxD                      | ASCK input  |
|        |     | 1   |       |        |      |        |        | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | $\times$ Note | (input)       | P72  |          |                    |                |                              |                              |                          |                          |   |
| Others |     |     |       |        |      |        |        |               |               |               |               |               |               |               |               |      |          | Setting prohibited |                |                              |                              |                          |                          |   |

**Note** These pins can be used as port pins.

**Remark**  $\times$  : don't care

PM $\times$ : port mode register

P $\times$  : output latch of port

**Figure 8-20. Format of Asynchronous Serial Interface Status Register**

( $\mu$ PD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 78083, 78098, 78098, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY, 78098B subseries,  $\mu$ PD78070A, 78070AY)



- Notes**
1. If an overrun error occurs, be sure to read the receive buffer register (RXB). The overrun error persists each time data is received until RXB is read.
  2. Even if the stop bit length is set to 2 bits by the bit 2 (SL) of the asynchronous serial interface mode register (ASIM), only 1 stop bit is detected during reception.

**Figure 8-21. Format of Baud Rate Generator Control Register**  
 ( $\mu$ PD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 78083, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY subseries,  $\mu$ PD78070A, 78070AY) (1/2)

|        |      |      |      |      |      |      |      |      |         |          |     |
|--------|------|------|------|------|------|------|------|------|---------|----------|-----|
| Symbol | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address | At reset | R/W |
| BRGC   | TPS3 | TPS2 | TPS1 | TPS0 | MDL3 | MDL2 | MDL1 | MDL0 | FF73H   | 00H      | R/W |

| MDL3 | MDL2 | MDL1 | MDL0 | Selects input clock of baud rate generator | k  |
|------|------|------|------|--|----|
| 0    | 0    | 0    | 0    | f <sub>sck</sub> /16                       | 0  |
| 0    | 0    | 0    | 1    | f <sub>sck</sub> /17                       | 1  |
| 0    | 0    | 1    | 0    | f <sub>sck</sub> /18                       | 2  |
| 0    | 0    | 1    | 1    | f <sub>sck</sub> /19                       | 3  |
| 0    | 1    | 0    | 0    | f <sub>sck</sub> /20                       | 4  |
| 0    | 1    | 0    | 1    | f <sub>sck</sub> /21                       | 5  |
| 0    | 1    | 1    | 0    | f <sub>sck</sub> /22                       | 6  |
| 0    | 1    | 1    | 1    | f <sub>sck</sub> /23                       | 7  |
| 1    | 0    | 0    | 0    | f <sub>sck</sub> /24                       | 8  |
| 1    | 0    | 0    | 1    | f <sub>sck</sub> /25                       | 9  |
| 1    | 0    | 1    | 0    | f <sub>sck</sub> /26                       | 10 |
| 1    | 0    | 1    | 1    | f <sub>sck</sub> /27                       | 11 |
| 1    | 1    | 0    | 0    | f <sub>sck</sub> /28                       | 12 |
| 1    | 1    | 0    | 1    | f <sub>sck</sub> /29                       | 13 |
| 1    | 1    | 1    | 0    | f <sub>sck</sub> /30                       | 14 |
| 1    | 1    | 1    | 1    | f <sub>sck</sub> <sup>Note</sup>           | –  |

**Note** Can be used only in the 3-wire serial I/O mode.

- Remarks**
1. f<sub>sck</sub>: source clock of 5-bit counter
  2. k : value set by MDL0 through MDL3 (0 ≤ k ≤ 14)

**Figure 8-21. Format of Baud Rate Generator Control Register**  
 (μPD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 78083, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY subseries, μPD78070A, 78070AY) (2/2)

| TPS3   | TPS2 | TPS1 | TPS0 | Selects source clock of 5-bit counter |                        |                        | n  |
|--------|------|------|------|---------------------------------------|------------------------|------------------------|----|
|        |      |      |      |                                       | MCS = 1                | MCS = 0                |    |
| 0      | 0    | 0    | 0    | $f_{xx}/2^{10}$                       | $f_x/2^{10}$ (4.9 kHz) | $f_x/2^{11}$ (2.4 kHz) | 11 |
| 0      | 1    | 0    | 1    | $f_{xx}$                              | $f_x$ (5.0 MHz)        | $f_x/2$ (2.5 MHz)      | 1  |
| 0      | 1    | 1    | 0    | $f_{xx}/2$                            | $f_x/2$ (2.5 MHz)      | $f_x/2^2$ (1.25 MHz)   | 2  |
| 0      | 1    | 1    | 1    | $f_{xx}/2^2$                          | $f_x/2^2$ (1.25 MHz)   | $f_x/2^3$ (625 kHz)    | 3  |
| 1      | 0    | 0    | 0    | $f_{xx}/2^3$                          | $f_x/2^3$ (625 kHz)    | $f_x/2^4$ (313 kHz)    | 4  |
| 1      | 0    | 0    | 1    | $f_{xx}/2^4$                          | $f_x/2^4$ (313 kHz)    | $f_x/2^5$ (156 kHz)    | 5  |
| 1      | 0    | 1    | 0    | $f_{xx}/2^5$                          | $f_x/2^5$ (156 kHz)    | $f_x/2^6$ (78.1 kHz)   | 6  |
| 1      | 0    | 1    | 1    | $f_{xx}/2^6$                          | $f_x/2^6$ (78.1 kHz)   | $f_x/2^7$ (39.1 kHz)   | 7  |
| 1      | 1    | 0    | 0    | $f_{xx}/2^7$                          | $f_x/2^7$ (39.1 kHz)   | $f_x/2^8$ (19.5 kHz)   | 8  |
| 1      | 1    | 0    | 1    | $f_{xx}/2^8$                          | $f_x/2^8$ (19.5 kHz)   | $f_x/2^9$ (9.8 kHz)    | 9  |
| 1      | 1    | 1    | 0    | $f_{xx}/2^9$                          | $f_x/2^9$ (9.8 kHz)    | $f_x/2^{10}$ (4.9 kHz) | 10 |
| Others |      |      |      | Setting prohibited                    |                        |                        |    |

**Caution** If data is written to BRGC during communication, the output of the baud rate generator is disturbed and communication cannot be executed normally. Therefore, do not write data to BRGC during communication.

- Remarks**
1.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  2.  $f_x$  : main system clock oscillation frequency
  3. MCS: bit 0 of oscillation mode select register (OSMS)
  4. n : value set by TPS0 through TPS3 ( $1 \leq n \leq 11$ )
  5. ( ) : at  $f_x = 5.0$  MHz

Figure 8-22. Format of Baud Rate Generator Control Register ( $\mu$ PD78098, 78098B subseries) (1/2)

|        |      |      |      |      |      |      |      |      |         |          |     |
|--------|------|------|------|------|------|------|------|------|---------|----------|-----|
| Symbol | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0    | Address | At reset | R/W |
| BRGC   | TPS3 | TPS2 | TPS1 | TPS0 | MDL3 | MDL2 | MDL1 | MDL0 | FF73H   | 00H      | R/W |

| MDL3 | MDL2 | MDL1 | MDL0 | Selects input clock of baud rate generator | k  |
|------|------|------|------|--|----|
| 0    | 0    | 0    | 0    | f <sub>sck</sub> /16                       | 0  |
| 0    | 0    | 0    | 1    | f <sub>sck</sub> /17                       | 1  |
| 0    | 0    | 1    | 0    | f <sub>sck</sub> /18                       | 2  |
| 0    | 0    | 1    | 1    | f <sub>sck</sub> /19                       | 3  |
| 0    | 1    | 0    | 0    | f <sub>sck</sub> /20                       | 4  |
| 0    | 1    | 0    | 1    | f <sub>sck</sub> /21                       | 5  |
| 0    | 1    | 1    | 0    | f <sub>sck</sub> /22                       | 6  |
| 0    | 1    | 1    | 1    | f <sub>sck</sub> /23                       | 7  |
| 1    | 0    | 0    | 0    | f <sub>sck</sub> /24                       | 8  |
| 1    | 0    | 0    | 1    | f <sub>sck</sub> /25                       | 9  |
| 1    | 0    | 1    | 0    | f <sub>sck</sub> /26                       | 10 |
| 1    | 0    | 1    | 1    | f <sub>sck</sub> /27                       | 11 |
| 1    | 1    | 0    | 0    | f <sub>sck</sub> /28                       | 12 |
| 1    | 1    | 0    | 1    | f <sub>sck</sub> /29                       | 13 |
| 1    | 1    | 1    | 0    | f <sub>sck</sub> /30                       | 14 |
| 1    | 1    | 1    | 1    | f <sub>sck</sub> <sup>Note</sup>           | –  |

**Note** Can be used only in the 3-wire serial I/O mode.

- Remarks**
1. f<sub>sck</sub> : source clock of 5-bit counter
  2. k : value set by MDL0 through MDL3 (0 ≤ k ≤ 14)

**Figure 8-22. Format of Baud Rate Generator Control Register ( $\mu$ PD78098, 78098B subseries) (2/2)**

| TPS3   | TPS2 | TPS1 | TPS0 | Selects source clock of 5-bit counter | n  |
|--------|------|------|------|---------------------------------------|----|
| 0      | 0    | 0    | 0    | $f_{xx}/2^{10}$ (3.91 kHz)            | 11 |
| 0      | 1    | 0    | 1    | $f_{xx}$ (4.0 MHz)                    | 1  |
| 0      | 1    | 1    | 0    | $f_{xx}/2$ (2.0 MHz)                  | 2  |
| 0      | 1    | 1    | 1    | $f_{xx}/2^2$ (1.0 MHz)                | 3  |
| 1      | 0    | 0    | 0    | $f_{xx}/2^3$ (500 kHz)                | 4  |
| 1      | 0    | 0    | 1    | $f_{xx}/2^4$ (250 kHz)                | 5  |
| 1      | 0    | 1    | 0    | $f_{xx}/2^5$ (125 kHz)                | 6  |
| 1      | 0    | 1    | 1    | $f_{xx}/2^6$ (62.5 kHz)               | 7  |
| 1      | 1    | 0    | 0    | $f_{xx}/2^7$ (31.3 kHz)               | 8  |
| 1      | 1    | 0    | 1    | $f_{xx}/2^8$ (15.6 kHz)               | 9  |
| 1      | 1    | 1    | 0    | $f_{xx}/2^9$ (7.81 kHz)               | 10 |
| Others |      |      |      | Setting prohibited                    |    |

**Caution** If data is written to BRGC during communication, the output of the baud rate generator is disturbed and communication cannot be executed normally.  
Therefore, do not write data to BRGC during communication.

- Remarks**
1.  $f_{xx}$  : main system clock frequency
  2. n : value set by TPS0 through TPS3 ( $1 \leq n \leq 11$ )
  3. ( ) : at  $f_{xx} = 4.0$  MHz



★

**Figure 8-23. Format of Serial Interface Pin Select Register  
( $\mu$ PD780058 and 780058Y Subseries)**

|        |   |   |        |        |   |   |   |   |         |          |     |
|--------|---|---|--------|--------|---|---|---|---|---------|----------|-----|
| Symbol | 7 | 6 | 5      | 4      | 3 | 2 | 1 | 0 | Address | At reset | R/W |
| SIPS   | 0 | 0 | SIPS21 | SIPS20 | 0 | 0 | 0 | 0 | FF75H   | 00H      | R/W |

| SIPS21 | SIPS20 | Selects I/O pin of asynchronous serial interface       |
|--------|--------|--|
| 0      | 0      | Input pin : RxD0/SI2/P70<br>Output pin : TxD0/SO2/P71  |
| 0      | 1      | Input pin : RxD1/BUSY/P24<br>Output pin : TxD0/SO2/P71 |
| 1      | 0      | Input pin : RxD0/SI2/P70<br>Output pin : TxD1/STB/P23  |
| 1      | 1      | Input pin : RxD1/BUSY/P24<br>Output pin : TxD1/STB/P23 |

- Cautions**
1. Change the mode of an I/O Pin after stopping the serial transfer/reception operation.
  2. When using the busy control option or busy & strobe control option in the 3-wire serial I/O mode with automatic transfer/reception function of the serial interface channel 1, the RxD1/BUSY/P24 and TxD1/STB/P23 pins cannot be used as data I/O pins.

★

**Figure 8-24. Format of Serial Interface Pin Select Register  
( $\mu$ PD780308 and 780308Y Subseries)**

|        |   |   |        |        |   |   |   |   |         |          |     |
|--------|---|---|--------|--------|---|---|---|---|---------|----------|-----|
| Symbol | 7 | 6 | 5      | 4      | 3 | 2 | 1 | 0 | Address | At reset | R/W |
| SIPS   | 0 | 0 | SIPS21 | SIPS20 | 0 | 0 | 0 | 0 | FF75H   | 00H      | R/W |

| SIPS21 | SIPS20 | Selects I/O pin of asynchronous serial interface    |
|--------|--------|---|
| 0      | 0      | Input pin : RxD/SI2/P70<br>Output pin : TxD/SO2/P71 |
| 0      | 1      | Input pin : RxD/P114<br>Output pin : TxD/SO2/P71    |
| 1      | 0      | Input pin : RxD0/SI2/P70<br>Output pin : TxD/P113   |
| 1      | 1      | Input pin : RxD/P114<br>Output pin : TxD/P113       |

- Cautions**
1. Change the mode of an I/O Pin after stopping the serial transfer/reception operation.
  2. Port 11 has a falling edge detection function. Do not input a falling edge to the pin used as a multiplexed pin of this port.

## 8.1 Interface with EEPROM™ ( $\mu$ PD6252)

The  $\mu$ PD6252<sup>Note</sup> is a 2048-bit EEPROM which can be electrically written or erased. To write or read data to or from the  $\mu$ PD6252, the 3-wire serial interface is used.

★ **Note**  $\mu$ PD6252 is for maintenance use.

**Figure 8-25. Pin Configuration of  $\mu$ PD6252**

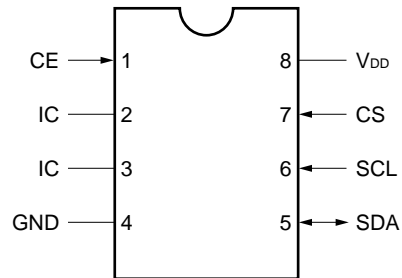
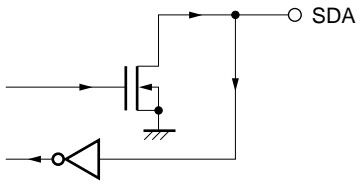


Table 8-7. Pin Function of  $\mu$ PD6252

| Pin Number | Pin Name        | I/O                                      | Function   |
|------------|-----------------|--|--|
| 1          | CE              | CMOS input                               | <p>Keep this pin high during data transfer.</p> <p><b>Caution</b> Do not change the level of this pin from high to low during data transfer.</p> <p>To change the level of this pin from high to low, make sure that the CS pin (pin 7) is low. By making both the CE and CS pins low, you can set the standby status in which the power consumption is reduced.</p>                                 |
| 2<br>3     | IC              | –  | Fix the IC pins to the high or low level via resistor.   |
| 4          | GND             | –  | Ground   |
| 5          | SDA             | CMOS input/<br>N-ch open-drain<br>output | <p>Data input/output pin.</p> <p>Because this pin is an N-ch open-drain I/O pin, externally pull it up with a resistor.</p>    |
| 6          | SCL             | CMOS input                               | Inputs a clock for data transfer.  |
| 7          | CS              | CMOS input                               | <p>Chip select pin. When this pin is high, the <math>\mu</math>PD6252 is enabled to operate. When it is low, memory cells cannot be read or written.</p> <p>When the level of this pin is changed from high to low with the SCL pin high, the operation of the serial bus interface is started. To end the operation of the serial bus interface, change the level of this pin from high to low.</p> |
| 8          | V <sub>DD</sub> | –  | Positive power: +5 V $\pm$ 10%   |

8.1.1 Communication in 2-wire serial I/O mode

The 3-wire mode of the  $\mu$ PD6252<sup>Note</sup> is implemented by serial clock (SCL), data (SDA), and chip select (CS) lines. Excluding the handshaking line, therefore, only two lines, clock and data lines, are necessary for interfacing. To interface the  $\mu$ PD6252 with a 78K/0 series microcontroller, the 2-wire serial I/O mode is used. In the example shown in this section, the  $\mu$ PD78054 subseries is used.

★ **Note**  $\mu$ PD6252 is for maintenance use.

Figure 8-26. Example of Connection of  $\mu$ PD6252

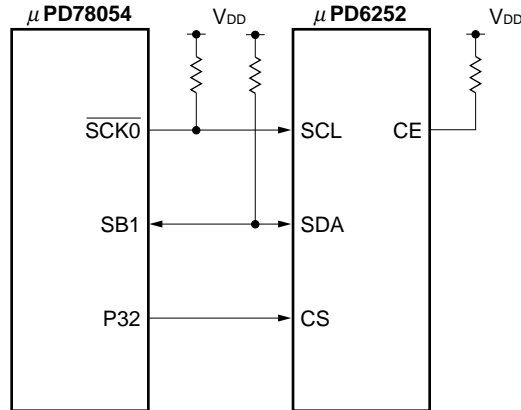


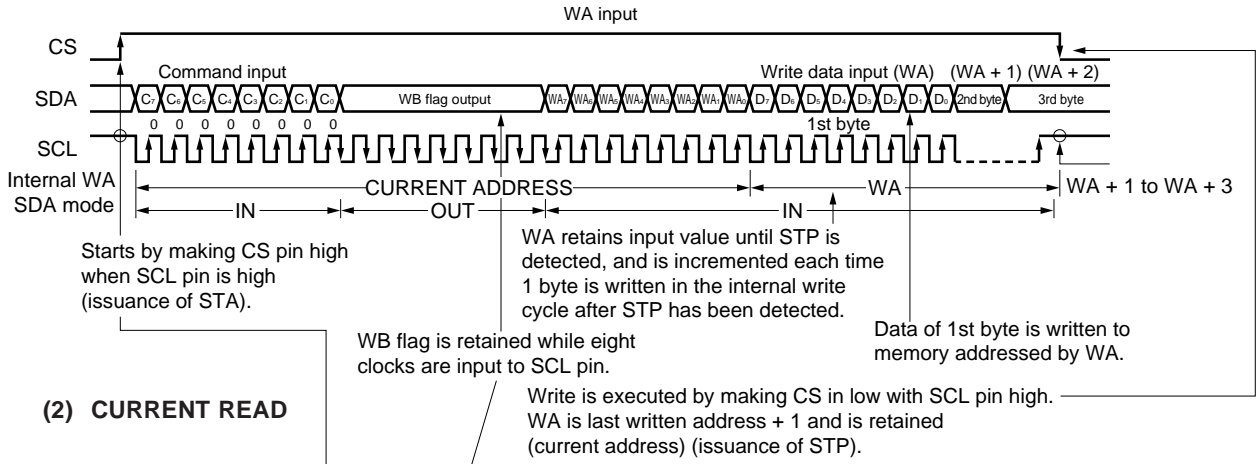
Table 8-8 and Figure 8-27 shows the commands to write and read data to/from the  $\mu$ PD6252 and communication format.

Table 8-8.  $\mu$ PD6252 Commands

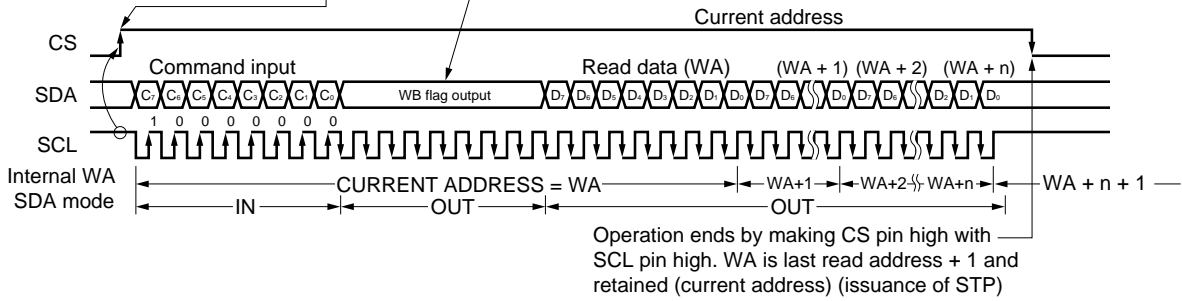
| Command Name | Command                        | Operation   |
|--------------|--------------------------------|---|
| RANDOM WRITE | 0000000B [00H]<br>MSB<br>C7-C0 | Transfers write data after setting an 8-bit word address (WA). Up to 3 bytes of write data can be set successively.<br><div style="border-left: 1px solid black; border-right: 1px solid black; padding: 5px; margin: 10px 0;">                     Correspondence between word address and data<br/>                     WA      Data of first byte<br/>                     WA+1    Data of second byte<br/>                     WA+2    Data of third byte                 </div> The write operation is executed in the internal write cycle after the CS pin has gone low. |
| CURRENT READ | 1000000B [80H]<br>MSB<br>C7-C0 | Transfers the contents of memory specified by the word address (WA) (current address) specified when the command is set, to the read data buffer. Each time 8 bits of data have been read from the SDA pin, the word address (WA) is incremented, and the corresponding memory contents are transferred to the data buffer.   |
| RANDOM READ  | 1100000B [C0H]<br>MSB<br>C7-C0 | Executes data read starting from a set word address (WA) after the word address has been set.<br>The difference from CURRENT READ is that this command sets a word address (WA) after it has been executed.<br>After the word address has been set, this command performs the same operation as CURRENT READ.   |

Figure 8-27. Communication Format of  $\mu$ PD6252

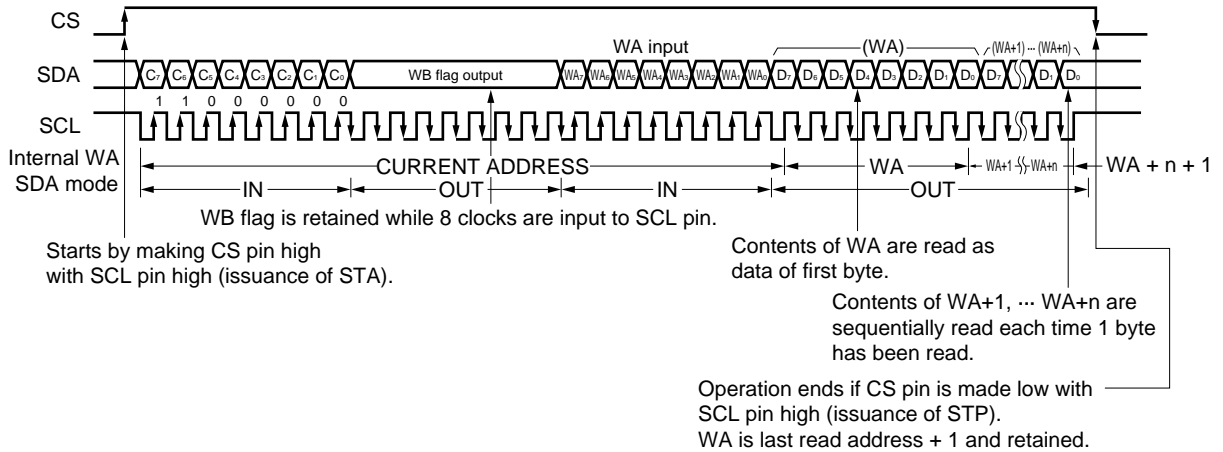
(1) RANDOM WRITE



(2) CURRENT READ



(3) RANDOM READ



Steps <1> through <5> below are the operating procedure of the  $\mu$ PD6252. In this example, the number of data to be written or read per interface operation is fixed to 1 byte. If the  $\mu$ PD6252 is in the write busy (WB) status when interfaced, the busy flag is set.

- <1> Make the CS pin (P32) high to start interfacing.
- <2> Transmit the write or read command.
- <3> Receive the data of WRITE BUSY. If interfacing the  $\mu$ PD6252 is enabled, 00H is received. If a code other than 00H is received, it is judged that the  $\mu$ PD6252 is in the WRITE BUSY status. In this case, communication is stopped.
- <4> Transfer the data corresponding to the command.
- <5> Make the CS pin (P32) low to end the communication.

**(1) Description of package**

**<Public declaration symbol>**

- T3\_6252 :  $\mu$ PD6252 transfer subroutine name
- RWRITE : RANDOM WRITE command value
- RREAD : RANDOM READ command value
- CREAD : CURRENT READ command value
- WADAT : Word address storage area
- TRNDAT : Transmit data storage area
- RCVDAT : Receive data storage area
- CMDDAT : Command data storage area
- BUSYFG : Busy status test flag
- CS6252 : CS pin (P32) of  $\mu$ PD6252

**<Register used>**

A

**<RAM used>**

| Name   | Usage   | Attribute | Bytes |
|--------|---|-----------|-------|
| WAADR  | Stores word address (before start of transfer)  | SADDR     | 1     |
| TRNDAT | Stores transmit data (before start of transfer) |           |       |
| RCVDAT | Stores receive data (after end of transfer)     |           |       |
| CMDDAT | Stores command data (before start of transfer)  |           |       |

**<Flag used>**

| Name   | Usage                  |
|--------|------------------------|
| BUSYFG | Sets WRITE BUSY status |

**<Nesting>**

1 level 3 bytes

**<Hardware used>**

- Serial interface channel 0
- P32

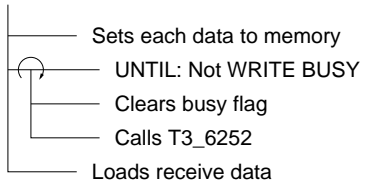
**<Initial setting>**

- OSMS = #00000001B ; Oscillation mode select register: does not use divider circuit
- Setting of serial interface channel 0  
CSIM0 = #10011011B ; Selects 2-wire serial I/O mode and SB1 pin
- TCL3 = #xxxx1001B ; Serial clock  $f_{xx}/2^4$
- RELT = 1 ; Makes SB1 latch high

**<Starting>**

Set the necessary data corresponding to the commands and call T3\_6252. After execution returns from the subroutine, the busy flag (BUSYFG) is tested. If the busy flag is set, transfer is not executed. It is therefore necessary to execute transfer again. In the receive mode, the receive data is stored RCVDAT after execution has returned from the subroutine.

(2) Example of use



```

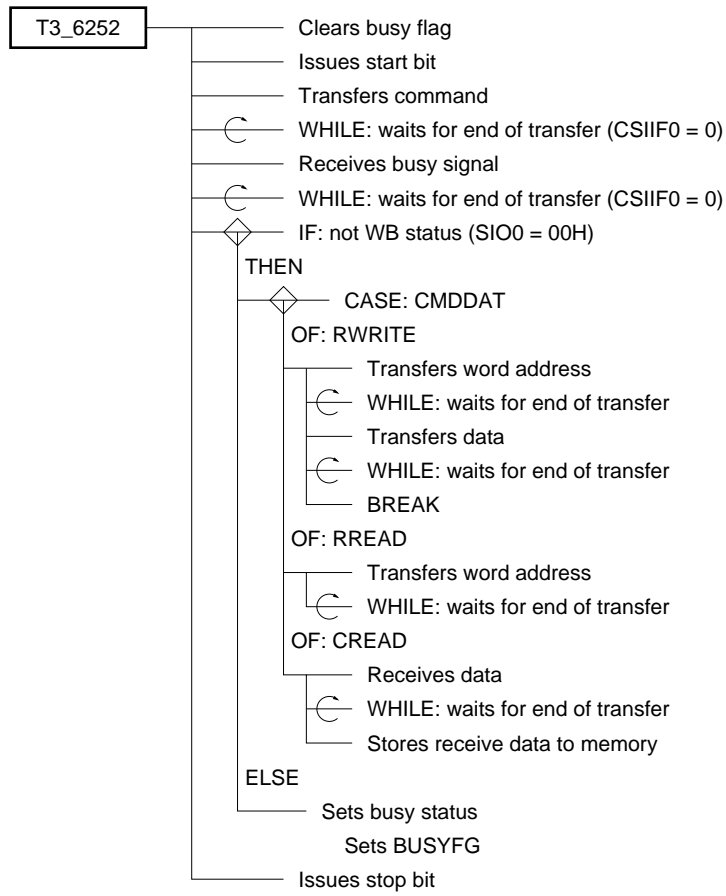
EXTRN    RWRITE, RREAD, CREAD
EXTRN    WADAT, TRNDAT, RCVDAT, CMDDAT, T3_6252
EXTBIT   BUSYFG, CS6252

OSMS=#00000001B           ; Does not use divider circuit
CSIM0=#10011011B         ; Sets 2-wire serial I/O mode and SB1 pin
TCL3=#10011001B         ; Sets SCK0 = 262 kHz
CLR1     SB0
CLR1     CS6252           ; Makes CS of μPD6252 low
CLR1     PM3.2

CMDDAT=A
:
:
:
WADAT=A
:
:
:
TRNDAT=A
:
:
:
repeat
    CLR1     BUSYFG
    CALL     !T3_6252
until_bit(!BUSYFG)
:
:
:
A=RCVDAT
    
```



(3) SPD chart



## (4) Program list

```

        PUBLIC RWRITE, RREAD, CREAD
        PUBLIC WADAT, TRNDAT, RCVDAT, CMDDAT, T3_6252
        PUBLIC BUSYFG, CS6252
CSI_DAT DSEG SADDR
WADAT: DS 1 ; Word address storage area
TRNDAT: DS 1 ; Transmit data storage area
RCVDAT: DS 1 ; Receive data storage area
CMDDAT: DS 1 ; Command data storage area

CSI_FLG BSEG
BUSYFG DBIT ; Sets busy status

RWRITE EQU 00H ; RANDOM WRITE mode
RREAD EQU 0C0H ; RANDOM READ mode
CREAD EQU 080H ; CURRENT READ mode
CS6252 EQU 0FF03H.2 ; 0FF03H=PORT3

CSI_SEG CSEG
;*****
;*  $\mu$ PD6252 (3-wire) communication
;*****
T3_6252:
    CLR1 BUSYFG
    SET1 CS6252 ; Issues start bit
    SIO0=CMDDAT (A) ; Transfers command
    while_bit(!CSIIF0) ; Waits for end of transfer
    endw
    CLR1 CSIIF0
    SIO0=#0FFH ; Starts reception of busy signal
    while_bit(!CSIIF0) ; Waits for end of transfer
    endw
    CLR1 CSIIF0
    if(SIO0==#00H) ; Busy check
        switch (CMDDAT)
            case RWRITE:
                SIO0=WADAT (A) ; Transfers word address
                while_bit(!CSIIF0) ; Waits for end of transfer
                endw
                CLR1 CSIIF0
                SIO0=TRNDAT (A) ; Starts data transfer
                while_bit(!CSIIF0) ; Waits for end of transfer
                endw
                CLR1 CSIIF0
            break
            case RREAD:
                SIO0=WADAT (A) ; Transfers word address
                while_bit(!CSIIF0) ; Waits for end of transfer
                endw
                CLR1 CSIIF0
            case CREAD:
                SIO0=#0FFH ; Starts data reception
                while_bit(!CSIIF0) ; Waits for end of transfer
                endw
                CLR1 CSIIF0
                RCVDAT=SIO0 (A) ; Stores receive data
        ends
    ends

```

```
else
    SET1    BUSYFG        ; Sets busy status
endif
CLR1     CS6252
RET
```

### 8.1.2 Communication in I<sup>2</sup>C bus mode

In the 2-wire mode of the  $\mu$ PD6252<sup>Note</sup>, two lines, serial clock (SCL) and data (SDA) lines are used for communication. This mode conforms to the communication format of I<sup>2</sup>C. Therefore, the I<sup>2</sup>C mode is selected when communicating with the  $\mu$ PD6252 by using the  $\mu$ PD78054Y, 78064Y, 78078Y, 780058Y, 780308Y, 78058FY, 78075BY subseries, or  $\mu$ PD78070AY.

In the example shown in this section, the  $\mu$ PD78054Y subseries is used.

★ **Note**  $\mu$ PD6252 is for maintenance use.

**Figure 8-28. Example of Connection between  $\mu$ PD6252 and I<sup>2</sup>C Bus Mode**

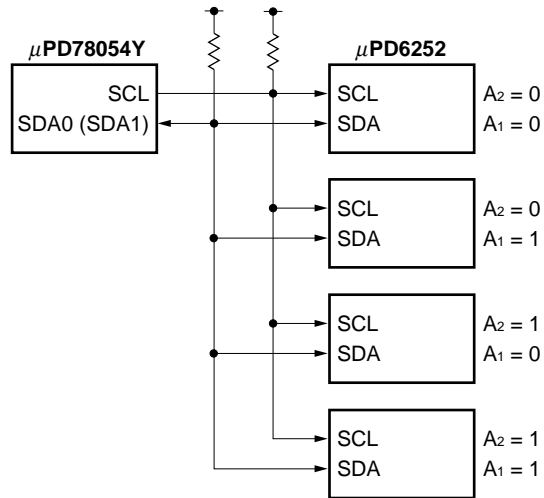
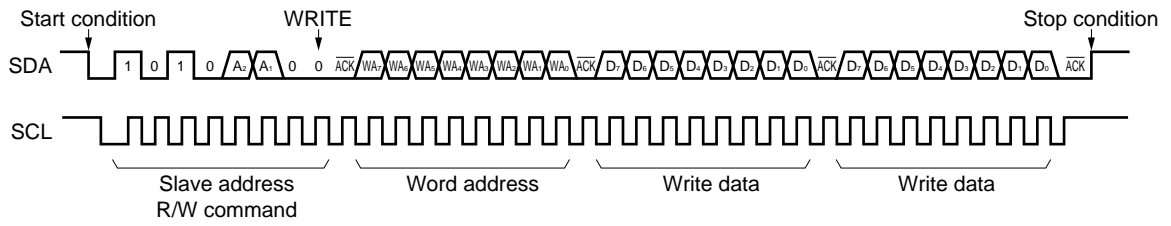


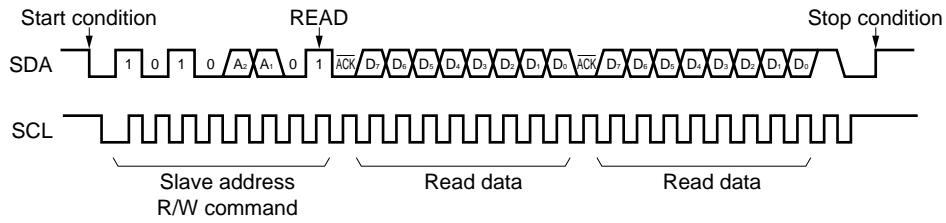
Figure 8-29 shows the communication format in which data is written to or read from the  $\mu$ PD6252.

Figure 8-29.  $\mu$ PD6252 Operation Timing

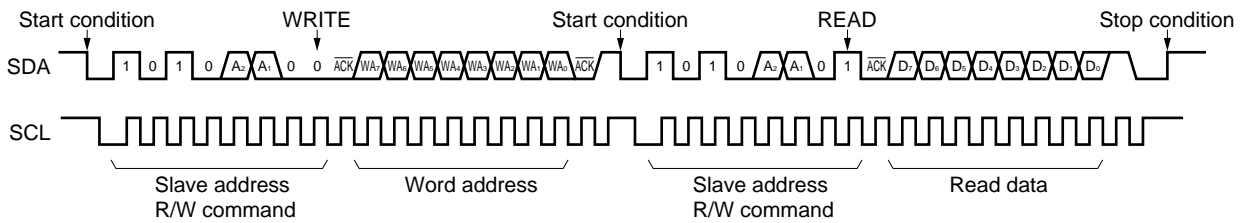
(a) Transmission to  $\mu$ PD6252



(b) Reception from  $\mu$ PD6252 (without word address specification)



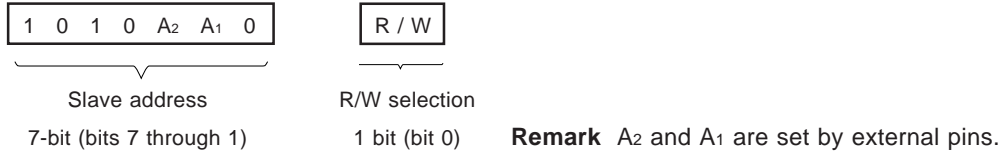
(c) Reception from  $\mu$ PD6252 (with word address specification)



Steps <1> through <5> below are the communication procedure of the  $\mu$ PD6252. In this example, the number of data to be written or read is fixed to 1 byte. If the master receives data in the I<sup>2</sup>C bus format, and if it has received the last data, the  $\overline{\text{ACK}}$  signal is not output. Because the master does not output the  $\overline{\text{ACK}}$  signal in this example, ACKE is always 0.

<1> Set a start condition to start communication.  
Fall the data with the serial clock high.

<2> Transmit the slave address value (bits 1 through 7) of the  $\mu$ PD6252 and write (bit 0 = 0)/read (bit 0 = 1) select bit.



<3> Transfer the data.

- In transmission mode
  - (i) Transmit the word address of the  $\mu$ PD6252.
  - (ii) Transmit the write data.

- In reception mode
  - Receive the read data.

<4> Set an end condition to end the communication.  
Rise the data with the serial clock high.

<5> Because a word address is specified only in the write mode, to read data by specifying an address, the address must be specified by once setting the write mode.

If the  $\mu$ PD6252 does not return the  $\overline{\text{ACK}}$  signal during data transfer, communication is stopped.

The start and end conditions are set by CLC when the serial clock is manipulated, and by RELT and CMDT when data is manipulated.

**(1) Description of package****<Public declaration symbol>**

T2\_6252 :  $\mu$ PD6252 transfer subroutine name  
 WAADR : Word address storage area  
 TRNDAT : Transmit data storage area  
 RCVDAT : Receive data storage area  
 SLVADR : Slave address storage area  
 BUSYFG : Busy status test flag  
 WRCHG : Write  $\rightarrow$  read mode change flag  
 ERRFG : Error status test flag

**<Register used>**

A

**<RAM used>**

| Name   | Usage   | Attribute | Bytes |
|--------|---|-----------|-------|
| WAADR  | Stores word address (before start of transfer)  | SADDR     | 1     |
| TRNDAT | Stores transmit data (before start of transfer) |           |       |
| RCVDAT | Stores receive data (after end of transfer)     |           |       |
| SLVADR | Stores slave address                            |           |       |

**<Flag used>**

| Name   | Usage                           |
|--------|---------------------------------|
| BUSYFG | Sets WRITE BUSY status          |
| WRCHG  | Changes write mode to read mode |
| ERRFG  | Sets error status               |

**<Nesting>**

1 level 2 bytes

**<Hardware used>**

Serial interface 0

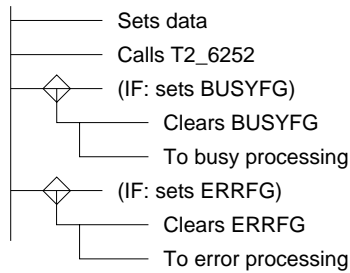
<Initial setting>

- OSMS = #00000001B ; Oscillation mode select register: does not use divider circuit
- Setting of serial interface channel 0  
CSIM0 = #10011011B ; Selects 2-wire serial I/O mode and SB0 pin
- TCL3 = #xxxx1000B ; Selects serial clock  $f_{xx}/2^3$  and 16
- SINT = #00001011B ; Generates interrupts at rising edge of 9th serial clock and sets clock line to high level

<Starting>

- Set the necessary data corresponding to the commands and call T2\_6252. In the reception mode, the receive data is stored to RCVDAT after execution has returned from the subroutine.
- If the serial clock is low (busy status) when communication is started or if ACK cannot be received during data transfer, the BUSYFG and ERRFG are set. Test and clear these flags with the main processing.

(2) Example of use



```

EXTRN  WAADR, TRNDAT, RCVDAT, SLVADR, T2_6252
EXTBIT  BUSYFG, WRCHG, ERRFG
  
```

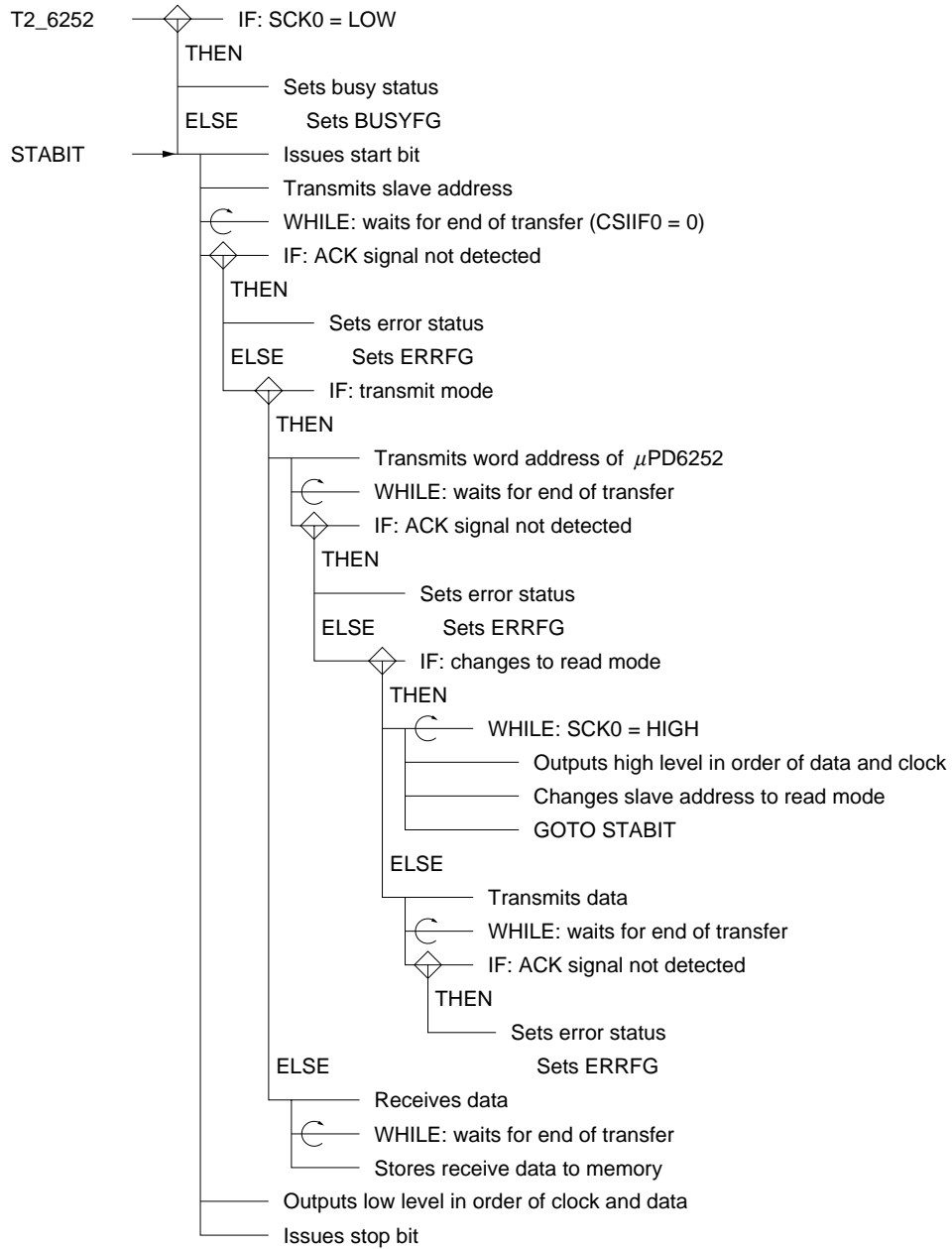
```

SET1   SB0
OSMS=#00000001B           ; Does not use divider circuit
CSIM0=#10011011B         ; Serial interface 2-wire, SB0
SINT=#00001011B         ; Sets I2C mode
TCL3=#10001000B         ; SCK = 32.7 kHz
SET1   RELT
SET1   SCK0
CLR1   SB0
:
:
WAADR=A
:
:
TRNDAT=A

SLVADR=A
CALL   !T2_6252
if_bit(BUSYFG)
    CLR1   BUSYFG
:
endif
:
if_bit(ERRFG)
    CLR1   ERRFG
:
ENDIF
  
```



(3) SPD chart



(4) Program list

```

PUBLIC  WAADR,TRNDAT,RCVDAT,SLVADR,T2_6252
PUBLIC  BUSYFG,WRCHG,ERRFG

CSI_DAT DSEG  SADDR
WAADR:  DS    1                ; Word address storage area
TRNDAT: DS    1                ; Transmit data storage area
RCVDAT: DS    1                ; Receive data storage area
SLVADR: DS    1                ; Slave address storage area

CSI_FLG BSEG
BUSYFG  DBIT                ; Sets busy status
WRCHG   DBIT                ; Changes mode
ERRFG   DBIT                ; Sets error status

SCK0    EQU    P2.7

CSI_SEG CSEG
;*****
;*  μPD6252 (2-wire) communication
;*****
T2_6252:
    if_bit(!CLD)
        SET1  BUSYFG        ; Busy status
    else
STABIT:
        SET1  CMDT        ; Issues start bit
        NOP                ; Waits for start bit valid width
        NOP
        NOP
        NOP
        CLR1  CLC          ; Changes clock to low level
        SIO0=SLVADR (A)    ; Starts transmitting slave address
        while_bit(!CSIIF0) ; Waits for end of transfer
        endw
        CLR1  CSIIF0
        if_bit(!ACKD)      ; ACK signal not detected
            SET1  ERRFG
        elseif_bit(!SLVADR.0) ; Transmission mode
            SIO0=WAADR (A) ; Starts transmitting word address
            while_bit(!CSIIF0) ; Waits for end of transfer
            endw
            CLR1  CSIIF0
            if_bit(!ACKD)  ; ACK signal not detected
                SET1  ERRFG
            elseif_bit(WRCHG)
                while_bit(CLD)
                endw
                SET1  RELT
                SET1  CLC
                while_bit(!CLD) ; Checks high level of clock
                endw
                NOP                ; Waits for high level valid width of clock
                NOP
                NOP
                NOP
                NOP
                NOP
                SET1  SLVADR.0 ; Changes to read mode address
                goto  STABIT
    else

```

```
        SIO0=TRNDAT (A)           ; Starts transmitting data
        while_bit(!CSIIF0)       ; Waits for end of transfer
        endw
        CLR1    CSIIF0
        if_bit(!ACKD)            ; ACK signal detected
            SET1    ERRFG
        endif
    endif
else
    SIO0=#0FFH                   ; Starts data reception
    while_bit(!CSIIF0)           ; Waits for end of transfer
    endw
    CLR1    CSIIF0
    RCVDAT=SIO0 (A)              ; Stores receive data
endif

while_bit(CLD)
endw
SET1    CMDT
SET1    CLC
while_bit(!CLD)                 ; Checks high level of clock
endw
NOP                                           ; Waits for high level valid width of clock
NOP
NOP
NOP
NOP
NOP
NOP
NOP
NOP
SET1    RELT                       ; Issues stop bit
endif
RET
```

★ (5) **Limitation when using I<sup>2</sup>C bus mode**

The following limitation applies when the  $\mu$ PD78054Y, 78064Y, 78078Y, 780058Y, 780308Y, 78058FY, 78075BY subseries, and  $\mu$ PD78070AY are used. This section explains an example using the  $\mu$ PD78054Y.

• **Limitation when the device is used as a slave device in the I<sup>2</sup>C bus mode**

**Description:** If the wake-up function is executed (by setting the WUP flag (bit 5 of serial operation mode register 0 (CSIM0) to 1) in the serial transfer status<sup>Note</sup>, the data between other slave device and the master devices is checked as an address. If that data coincides with the slave address of the  $\mu$ PD78054Y, therefore, the  $\mu$ PD78054Y takes part in communication, destroying the communication data.

**Note** The serial transfer status is the status from when the serial I/O shift register 0 (SIO0) has been written until the interrupt request flag (CSIIF0) is set to 1 by completion of serial transfer.

**Preventive measures:** The above problem can be prevented by modifying the program.

Before executing the wake-up function, execute the following program that clears the serial transfer status. When executing the wake-up function, do not execute an instruction that writes data to SIO0. Even if such an instruction is executed, data can be received when the wake-up function is executed.

This program is to clear the serial transfer status. To clear the serial transfer status, serial interface channel 0 must be stopped (by clearing the CSIE0 flag (bit 7 of the serial operation mode register (CSIM0) to 0). If the serial interface channel 0 is stopped in the I<sup>2</sup>C bus mode, however, the SCL pin outputs a high level and the SDA0 (SDA1) pin outputs a low level, affecting communication on the I<sup>2</sup>C bus. Therefore, this program allows the SCL and SDA0 (SDA1) pin to go into a high-impedance state to prevent the I<sup>2</sup>C bus from being affected.

Note that, in this example, the serial data input/output pin is SDA0 (/P25). If SDA1 (/P26) is used as the serial data input/output pin, take P2.5 and PM2.5 in the program as P2.6 and PM2.6.

- **Example of program that clears serial transfer status**

```
SET1 P2.5 ; <1>
SET1 PM2.5 ; <2>
SET1 PM2.7 ; <3>
CLR1 CSIE0 ; <4>
SET1 CSIE0 ; <5>
SET1 RELT ; <6>
CLR1 PM2.7 ; <7>
CLR1 P2.5 ; <8>
CLR1 PM2.5 ; <9>
```

- <1> When the I<sup>2</sup>C bus mode is restored by instruction <5>, the SDA0 pin does not output a low level. The output of the SDA0 pin goes into a high-impedance state.
- <2> The P25(/SDA0) pin is set in the input mode to prevent the SDA0 line from being affected when the port mode is set by instruction <4>. The P25 pin is set in the input mode when instruction <2> is executed.
- <3> The P27 (/SCL) pin is set in the input mode to prevent the SCL line from being affected when the port mode is set by instruction <4>. The P27 pin is set in the input mode when instruction <3> is executed.
- <4> The I<sup>2</sup>C bus mode is changed to the port mode.
- <5> The port mode is changed to the I<sup>2</sup>C bus mode.
- <6> Instruction <8> prevents the SDA0 pin from outputting a low level.
- <7> The P27 pin is set in the output mode because it must be in the output mode in the I<sup>2</sup>C bus mode.
- <8> The output latch of the P25 pin is cleared to 0 because it must be cleared to 0 in the I<sup>2</sup>C bus mode.
- <9> The P25 pin is set in the output mode because it must be in the output mode in the I<sup>2</sup>C bus mode.

**Remark** RELT: Bit 0 of serial bus interface control register (SBIC)

## 8.2 Interface with OSD LSI ( $\mu$ PD6451A)

The OSD (On Screen Display) LSI  $\mu$ PD6451A displays the program information of a VCR and TV channels on a display when used in combination with a microcontroller. The  $\mu$ PD6451A is interface with four lines: DATA, CLK, STB, and BUSY. In the example shown in this section, the  $\mu$ PD78054 subseries is used to interface the  $\mu$ PD6451A.

Figure 8-30. Example of Connecting  $\mu$ PD6451A

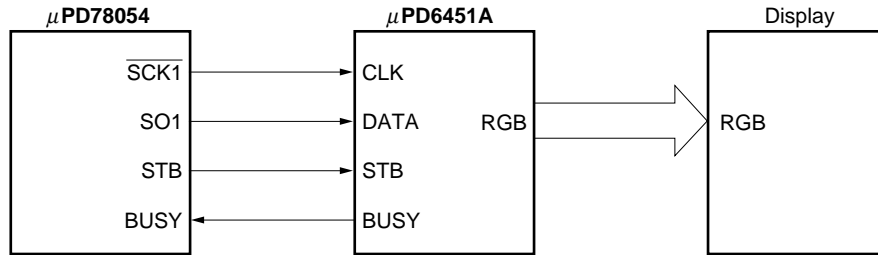
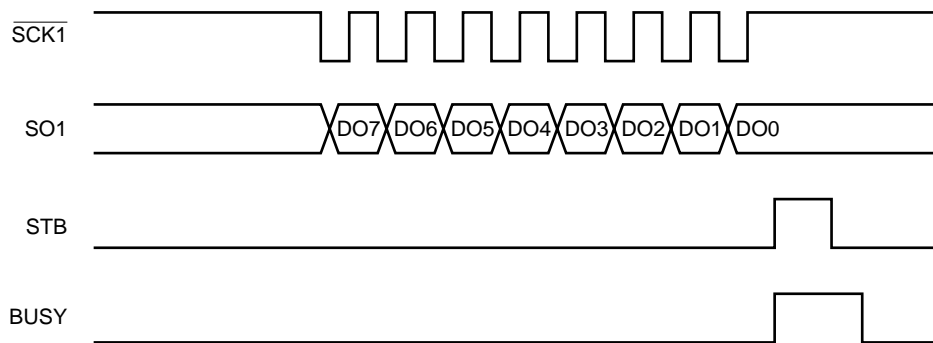


Figure 8-31. Communication Format of  $\mu$ PD6451A



The strobe signal (STB) is output and busy signal (BUSY) is tested automatically by the serial interface channel 1 of the 78K/0 series to establish handshaking with and to interface the  $\mu$ PD6451A. To match the communication format of the  $\mu$ PD6451A, the  $\mu$ PD78054 subseries is set in a mode in which output of the strobe signal and input of the busy signal (high active) are enabled. By setting the transmit data (32 bytes MAX) in a buffer area (FAC0H through FADFH) and the number of transmit data to the automatic data transmit/receive address pointer (ADTP), you can automatically transmit plural data successively.

**(1) Description of package****<Public declaration symbol>**

TR6451 :  $\mu$ PD6451A transfer subroutine name  
 DTVAL : Number of transmit data setting area

**<Register used>**

A

**<RAM used>**

| Name  | Usage                          | Attribute | Bytes |
|-------|--------------------------------|-----------|-------|
| DTVAL | Stores number of transmit data | SADDR     | 1     |

**<Nesting>**

1 level 2 bytes

**<Hardware used>**

- Serial interface channel 1

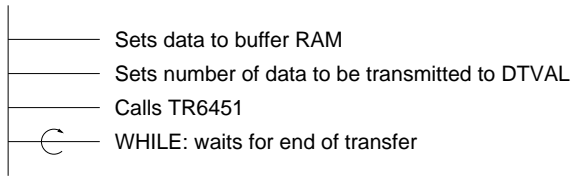
**<Initial setting>**

- Setting of serial interface channel 1
  - CSIM1 = #10100011B ; Enables automatic transmission/reception with MSB first
  - ADTC = #00000110B ; Enables busy input (high active) and strobe output in single mode
- ADTI = #00000000B ; Interval time of data transfer
- OSMS = #00000001B ; Oscillation mode select register; does not use divider circuit
- TCL3 = #1001xxxxB ; Serial clock  $f_{xx}/2^4$
- Makes P22 output latch high
- PM2 = #xxx1000xB ; Sets P21, P22, and P23 in output mode and P24 in input mode

**<Starting>**

Set the data to be transmitted to the buffer RAM (starting from the highest address), and the number of data to be transmitted to DTVAL, and call TR6451. You can check the end of data transfer by testing the bit 3 (TRF) of the automatic data transfer/reception control register (ADTC).

(2) Example of use



```

EXTRN    TR6451 ,DTVAL

SCK1    EQU    P2.2
        .
        .
        .
OSMS=#00000001B           ; Does not use divider circuit
P2=#00000100B
PM2=#11110001B
CSIM1=#10100011B         ; Sets automatic transfer/reception function
TCL3=#10011001B         ; SCK1 = 262 kHz
ADTC=#00000110B         ; Enable strobe and busy signals
ADTI=#00000000B         ; Interval time of data transfer
        .
        .
        .
DE=#TABLE1                ; Sets table reference address of transmit data
HL=#0FAC0H                ; Sets first address of buffer RAM
B=32                      ; Sets number of data to be transmitted

while(B>#0)                ; Transfers transmit data to buffer RAM
    B--
    [HL+B]=[DE] (A)
    DE++
endw

DATVAL=#32                ; Sets number of data to be transmitted
CALL    !TR6451
while_bit(TRF)            ; Waits for end of transfer
endw

```

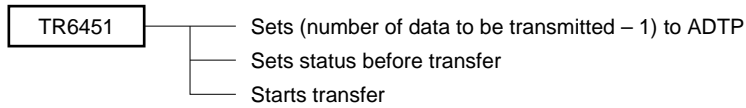


TABLE1 :

|    |           |  |
|----|-----------|--|
| DB | 11111111B | ; Power-ON reset, command 1                          |
| DB | 01000000B | ; Vertical address 0                                 |
| DB | 11000000B | ; Horizontal address 0                               |
| DB | 10000000B | ; Character size                                     |
| DB | 11111100B | ; Command 0  |
| DB | 11101001B | ; Turns LC transmission ON, blinking OFF, display ON |
| DB | 10001100B | ; Turns blinking ON. Character: red                  |
| DB | 11011011B | ; Color specification, background filled in cyan     |
| DB | 10010101B | ; Number of display lines: 5                         |
| DB | 10100000B | ; Number of display digits: 0                        |
| DB | 07H       | ; 7  |
| DB | 08H       | ; 8  |
| DB | 1BH       | ; K  |
| DB | 6DH       | ; /  |
| DB | 00H       | ; 0  |
| DB | 10H       |  |
| DB | 11H       | ; A  |
| DB | 20H       | ; P  |
| DB | 20H       | ; P  |
| DB | 1CH       | ; L  |
| DB | 19H       | ; I  |
| DB | 13H       | ; C  |
| DB | 11H       | ; A  |
| DB | 24H       | ; T  |
| DB | 19H       | ; I  |
| DB | 00H       | ; O  |
| DB | 1EH       | ; N  |
| DB | 10H       |  |
| DB | 1EH       | ; N  |
| DB | 00H       | ; O  |
| DB | 24H       | ; T  |
| DB | 15H       | ; E  |

**Remark** For the command and data of the output table data, refer to  $\mu$ PD6451A Data Sheet (Document No. IC-2337).

(3) SPD chart



(4) Program list

```

PUBLIC TR6451,DTVAL

CSI_DAT DSEG SADDR
DTVAL: DS 1 ; Number of data setting area

CSI_SEG CSEG
;*****
;* μPD6451A communication
;*****
TR6451:
    A=DTVAL ; Sets number of data
    A--
    ADTP=A
    SIO1=#0FFH ; Starts transfer
    RET
  
```

### 8.3 Interface in SBI Mode

The 78K/0 series has an SBI mode conforming to NEC serial bus format. In this mode, one master CPU can communicate with two or more slave CPUs by using two lines: clock and data. In the example shown in this section, the  $\mu$ PD78054 subseries is used.

Figure 8-32 shows an example of connection to use the SBI mode, and Figure 8-33 shows the communication format.

Figure 8-32. Example of Connection in SBI Mode

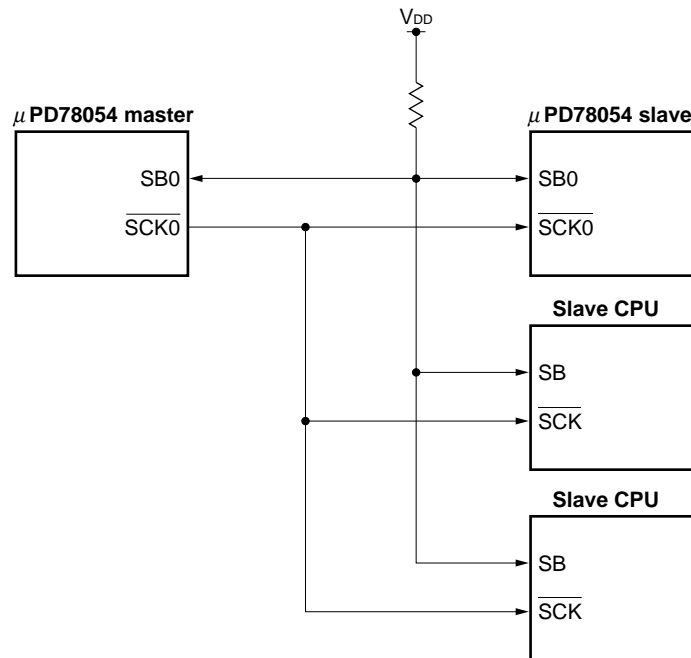
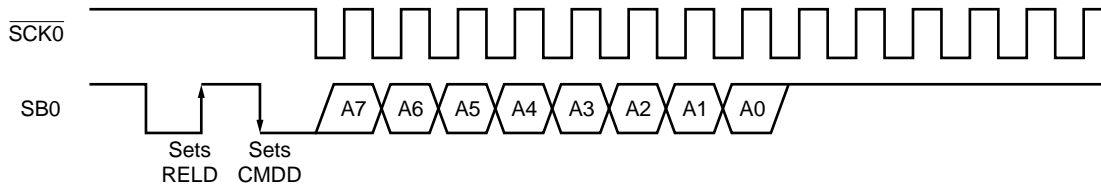
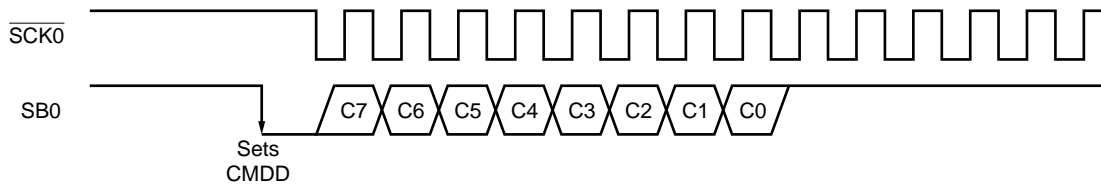


Figure 8-33. Communication Format in SBI Mode

## (a) Address transmission



## (b) Command transmission



## (c) Data transmission/reception

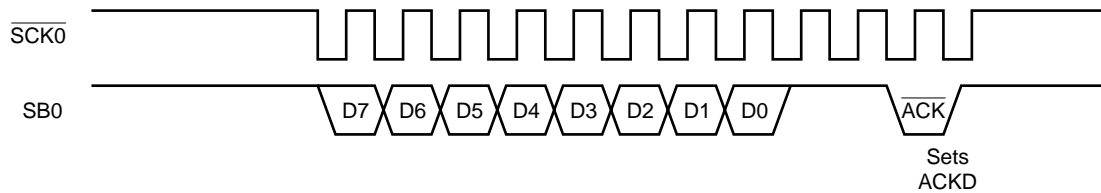


Table 8-9. Signals in SBI Mode

| Signal Name              | Output by:                    | Meaning   |
|--------------------------|-------------------------------|---|
| Address                  | Master                        | Selects slave device                                      |
| Command                  | Master                        | Command to slave device                                   |
| Data                     | Master/slave                  | Data to be processed by slave or master                   |
| Clock                    | Master                        | Serial data transmission/reception synchronization signal |
| $\overline{\text{ACK}}$  | Receiver side <sup>Note</sup> | Reception acknowledge signal                              |
| $\overline{\text{BUSY}}$ | Slave                         | Busy status   |

**Note** This signal is output by the receiver side during normal operation. However, it is output by the master CPU in case of an error such as time out.

**8.3.1 Application as master CPU**

When the  $\mu$ PD78054 subseries is used as a master CPU, it performs processing (a) through (d) below with respect to slave CPUs.

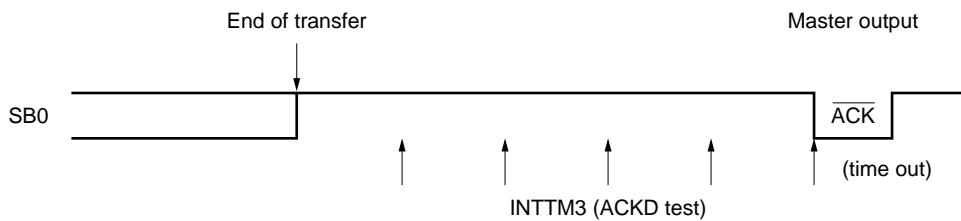
- (a) Address transmission
- (b) Command transmission
- (c) Data transmission
- (d) Data reception

While the above processing is performed, errors <1> and <2> below are checked.

<1> Time out processing

If the master CPU transmits data and a slave does not return the  $\overline{\text{ACK}}$  signal within a specific time (in this example, before the watch interrupt request occurs five times), the master judges that an error has occurred. The master CPU then outputs an  $\overline{\text{ACK}}$  signal and terminates the processing.

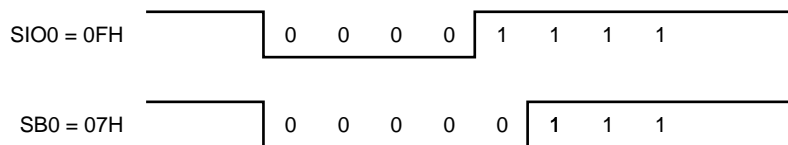
**Figure 8-34.  $\overline{\text{ACK}}$  Signal in Case of Time out**



<2> Testing bus line

The master CPU tests whether data has been correctly output to the bus line by setting the transmit data to the serial I/O shift register 0 (SIO0) and the slave address register (SVA). Because the data on the bus line is received by SIO0, it confirms that the data has been output normally by testing bit 6 (COI) of the serial operating mode register 0 (CSIM0) (that is set when SIO0 coincides with SVA) at the end of transfer.

**Figure 8-35. Testing Bus Line**



In Figure 8-35, the values of SIO0 and SVA do not coincide (SIO0 = 07H and SVA = 0FH). Consequently, COI = 0, and an error has occurred on the bus line.

(1) Description of package

<Public declaration symbol>

M\_TRANS : Master SBI transfer subroutine name  
 TR\_MODE : Storage area of transfer mode select value  
 TRNDAT : Transmit data storage area  
 RCVDAT : Receive data storage area  
 TRADR : Address transmit mode select value  
 TRCMD : Command transmit mode select value  
 TRDAT : Data transmit mode select value  
 RCDAT : Data reception mode select value  
 ERRORF : Error status test flag

<Register used>

Subroutine A

<RAM used>

| Name    | Usage                             | Attribute | Bytes |
|---------|-----------------------------------|-----------|-------|
| TR_MODE | Stores transfer mode select value | SADDR     | 1     |
| ACKCT   | Time out counter                  |           |       |
| TRNDAT  | Stores transmit data              |           |       |
| RCVDAT  | Stores receive data               |           |       |

<Flag used>

| Name   | Usage   |
|--------|---|
| RCVFLG | Sets reception mode                             |
| BUSYFG | Sets busy status                                |
| ERRORF | Sets error status                               |
| ACKWFG | Sets $\overline{\text{ACK}}$ signal wait status |

<Nesting>

2 levels 5 bytes

**<Hardware used>**

- Serial interface channel 0
- Watch timer

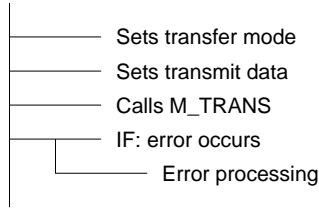
**<Initial setting>**

- OSMS=#00000001B ; Oscillation mode select register: does not use divider circuit
- Sets serial interface channel 0  
CSIM0=#10010011B ; Selects SBI mode and SB1 pin
- TCL3=#xxxx1001B ; Serial clock:  $f_{xx}/2^4$
- RELT=1 ; Makes SO0 latch high
- P27=1 ; Makes P27 output latch high
- TMC2=#00100110B ; Watch timer interval: 1.95 ms
- Enables watch timer interrupt

**<Starting>**

Set the transfer mode and necessary data, and call M\_TRANS. When execution has returned from the subroutine, occurrence of a transfer error can be checked by testing the error flag (ERRORF). In the reception mode, the receive data is stored to RCVDAT after execution has returned from the subroutine.

(2) Example of use



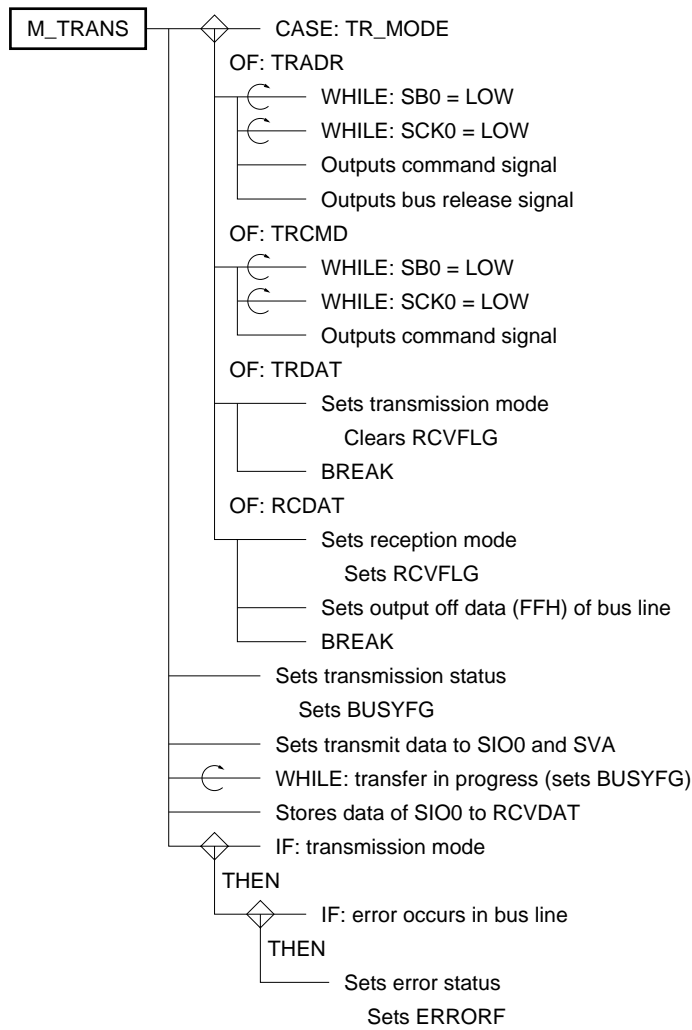
```

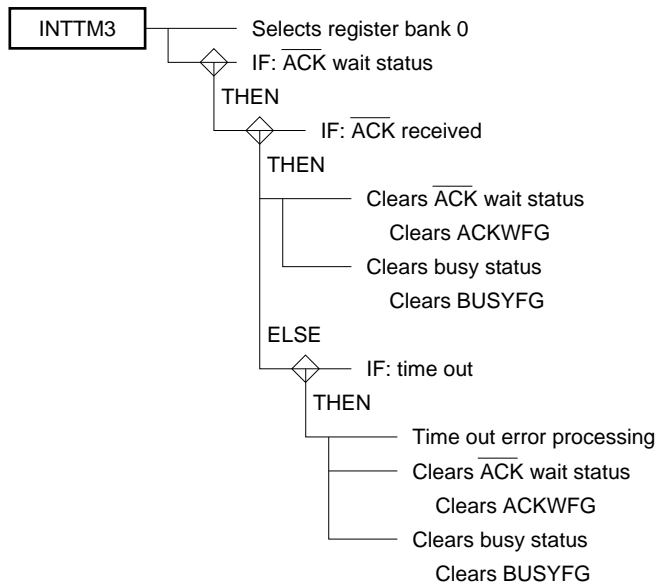
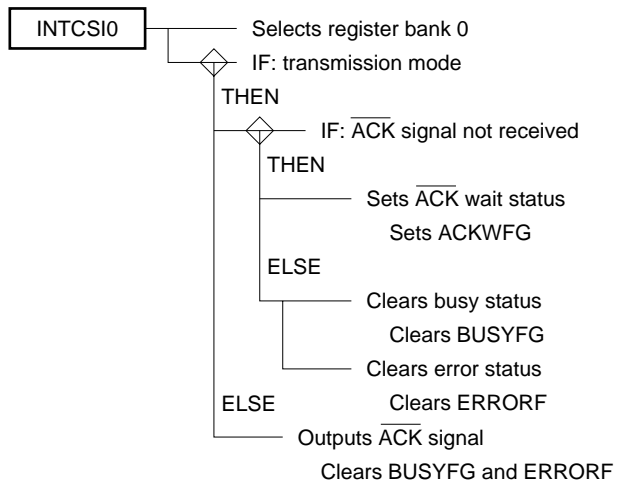
EXTRN  M_TRANS , TR_MODE , TRADR , TRCMD , TRDAT , RCDAT
EXTRN  TRNDAT , RCVDAT
EXTBIT  ERRORF

SCK0    EQU    P2.7
SB1     EQU    P2.5
      .
      .
OSMS=#00000001B      ; Does not use divider circuit
SET1    SB1
CSIM0=#10010111B    ; Operates in SBI mode
TCL3=#10011001B     ; SCK0 = 262 kHz
TMC2=#00100110B     ; Sets interval of watch timer to 1.95 ms
CLR1    BSYE        ; Disables output of busy signal
SET1    RELT        ; Sets output latch
SET1    SCK0
CLR1    SB1
CLR1    CSIMK0      ; Enables serial interface channel 0 interrupt
CLR1    TMMK3      ; Enables watch timer interrupt
EI      ; Enables master interrupt
      .
      .
TR_MODE=#TRADR
TRNDAT=#5AH
CALL    !M_TRANS
if_bit(ERRORF)
    Error processing
endif
    
```



(3) SPD chart





**(4) Program list**

```

PUBLIC M_TRANS, TR_MODE, TRADR, TRCMD, TRDAT, RCDAT
PUBLIC TRNDAT, RCVDAT, ERRORF

VECSI0 CSEG AT 14H
        DW INTCSI0 ; Sets vector address of serial interface channel 0
VETM3 CSEG AT 1EH
        DW INTTM3 ; Sets vector address of watch timer

SBI_DAT DSEG SADDR
TRNDAT: DS 1 ; Transmit data
RCVDAT: DS 1 ; Receive data
TR_MODE: DS 1 ; Sets transfer mode
ACKCT: DS 1 ; ACK time out count

SBI_FLG BSEG
RCVFLG DBIT ; Sets reception mode
BUSYFG DBIT ; Transfer status
ERRORF DBIT ; Error display
ACKWFG DBIT ; ACK wait status

SB0 EQU P2.5
SCK0 EQU P2.7

TRADR EQU 1 ; Selects address transmission mode
TRCMD EQU 2 ; Selects command transmission mode
TRDAT EQU 3 ; Selects data transmission mode
RCDAT EQU 4 ; Selects data reception mode

```

```

;*****
;*      SBI data transfer processing
;*****
SBI_SEG CSEG
M_TRANS:
    switch(TR_MODE)
    case TRADR:
        SET1    PM2.5
        while_bit(!SB0)                ; SB0 = high?
        CLR1    PM2.5
        endw
        while_bit(!SCK0)              ; SCK = high?
        endw
        SET1    CMDT                  ; Outputs command signal
        NOP                                ; Wait
        SET1    RELT                  ; Outputs bus release signal
        A=#TRCMD
    case TRCMD:
        SET1    PM2.5
        while_bit(!SB0)                ; SB0 = high?
        CLR1    PM2.5
        endw
        while_bit(!SCK0)              ; SCK = high?
        endw
        SET1    CMDT                  ; Outputs command signal
        A=#TRDAT
    case TRDAT:
        CLR1    RCVFLG                ; Sets transmission mode
        A=TRNDAT                      ; Sets transmit data
        break
    case RCDAT:
        SET1    RCVFLG                ; Sets reception mode
        MOV     A,#0FFH                ; Turns off receive buffer
        break
    ends

    SET1    BUSYFG                    ; Sets transfer status
    SVA=A                              ; Tests bus line
    SIO0=A                              ; Starts transfer

    while_bit(BUSYFG)                 ; Transfer in progress
    endw
    RCVDAT=SIO0 (A)                   ; Stores receive data
    if_bit(!RCVFLG)                   ; Transmission mode
        if_bit(!COI)                  ; Bus line output abnormal
            SET1    ERRORF             ; Sets error status
        endif
    endif
    RET

```

```

;*****
;*      INTCSIO interrupt processing
;*****
CSI_SEG CSEG
INTCSIO:
    SEL R0
    if_bit(!RCVFLG)                ; Transmission mode
        if_bit(!ACKD)              ; Acknowledge signal not received
            ACKCT=#5                ; Sets acknowledge signal wait status
            SET1    ACKWFG
        else
            CLR1    BUSYFG          ; Clears busy status
            CLR1    ERRORF         ; Clears error status
        endif
    else
        SET1    ACKT                ; Outputs acknowledge signal
        CLR1    BUSYFG              ; Clears busy status
        CLR1    ERRORF              ; Clears error status
    endif
    RET

;*****
;*      Time out processing
;*****
TM3_SEG CSEG
INTTM3:
    SEL R0
    if_bit(ACKWFG)                  ; Acknowledge signal wait status?
        if_bit(ACKD)                ; Acknowledge signal received?
            CLR1    ACKWFG           ; Clears acknowledge signal wait status
            CLR1    BUSYFG           ; Clears busy status
        else
            ACKCT--
            if(ACKCT==#0)            ; Time out?
                SET1    ACKT         ; Time out error processing
                SET1    ERRORF
            else
                CLR1    ACKWFG       ; Clears acknowledge signal wait status
                CLR1    BUSYFG       ; Clears busy status
            endif
        endif
    endif
endif

```



<Starting>

The interrupt processing is started by generation of INTCSI0. The interrupt processing performs the following processing:

- Identifies address/command/data
- Outputs  $\overline{\text{ACK}}$  signal
- Stores receive data to RCVDAT

(2) Example of use

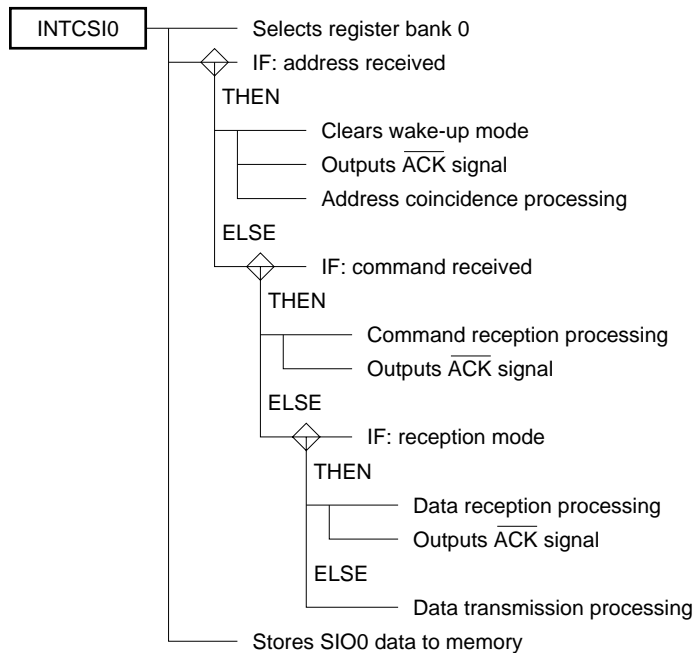
```

EXTRN  RCVDAT
EXTBIT  RCVFLG

SLVADR  EQU  5AH
SB1     EQU  P2.5

      :
      :
SET1    SB1
CSIM0=#10110100B ; Inputs external clock, sets SB1 pin, and selects wake-up mode
SET1    RELT      ; Sets output latch to high level
SET1    BSYE     ; Sets busy automatic output
SVA=#SLVADR      ; Sets slave address
SIO0=#0FFH      ; Serial transfer start command
CLR1    SB1
CLR1    CSIMK0   ; Enables serial interface channel 0 interrupt
EI      ; Enables master interrupt
    
```

(3) SPD chart



(4) Program list

```

VECSIO  CSEG  AT 14H
        DW    INTCSIO                ; Sets vector address of serial
                                       interface channel 0

SCI_DAT DSEG  SADDR
RCVDAT: DS    1                    ; Receive data storage area

CSI_FLG BSEG
RCVFLG  DBIT                        ; Sets reception mode

CSI_SEG CSEG
;*****
;*      INTCSIO interrupt processing
;*****
INTCSIO:
        SEL RBO
        if_bit(RELD)                ; To address reception
            CLR1      WUP            ; Clears wake-up mode
            SET1      ACKT          ; Outputs acknowledge signal
;      User processing (address reception)

;*****

        elseif_bit(CMDD)            ; To command reception
;      User processing (command reception)

            SET1      ACKT          ; Outputs acknowledge signal
        else

            if_bit(RCVFLG)
;      User processing (data reception processing)
            SET1      ACKT          ; Outputs acknowledge signal
        else
;      User processing (data transmission processing)
        endif
;*****
        endif
        RCVDAT=SIO0 (A)

        RETI

```



### 8.4 Interface in 3-Wire Serial I/O Mode

In this section, examples of communication between the master and a slave by using the 3-wire serial I/O mode (serial clock, data input, data output) of the serial channel 0 of the 78K/0 series are shown. In these examples, one extra busy signal is used as a handshake signal for simultaneous transmission/reception between the master and slave. This busy signal is active-low and is output by the slave. The data is 8 bits long and transmitted with the MSB first. In the examples in this section, the  $\mu$ PD78054 subseries is used.

Figure 8-36. Example of Connection in 3-Wire Serial I/O Mode

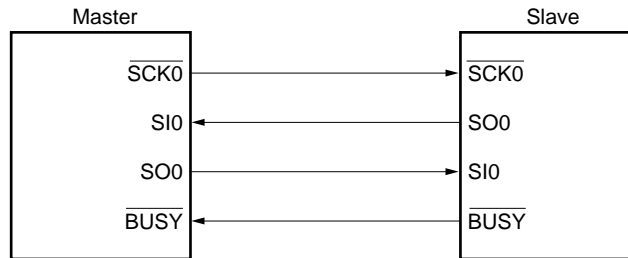
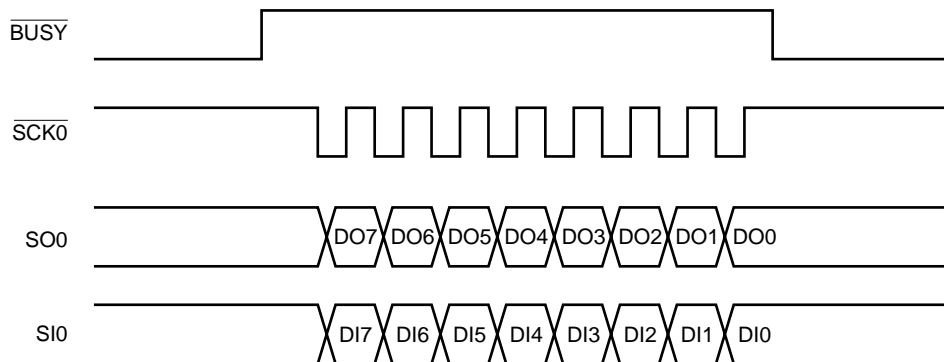


Figure 8-37. Communication Format in 3-Wire Serial I/O Mode



**8.4.1 Application as master CPU**

The serial clock is set to  $f_{xx}/2^4$ , and communication is executed in synchronization with this serial clock between the master and slave CPUs.

The master CPU starts transmission after it has set the transmit data. If the slave CPU is busy (when the busy signal is low), however, the master does not transmit data and sets the busy flag (BUSYFG).

**(1) Description of package**

**<Public declaration symbol>**

- TRANS : Name of 3-wire transfer subroutine of master
- TDATA : Transmit data storage area
- RDATA : Receive data storage area
- BUSY : Busy signal input port
- TREND : Transfer end test flag
- BUSYFG : Busy status test flag

**<Register used>**

- Interrupt : Bank 0, A
- Subroutine : A

**<RAM used>**

| Name  | Usage                | Attribute | Bytes |
|-------|----------------------|-----------|-------|
| TDATA | Stores transmit data | SADDR     | 1     |
| RDATA | Stores receive data  |           |       |

**<Flag used>**

| Name   | Usage                    |
|--------|--------------------------|
| TREND  | Sets transfer end status |
| BUSYFG | Sets busy status         |

**<Nesting>**

2 levels 5 bytes

**<Hardware used>**

- Serial interface channel 0
- P33

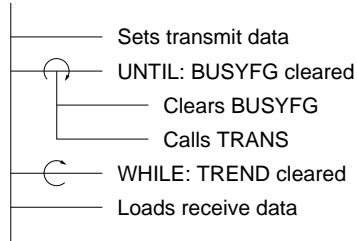
**<Initial setting>**

- OSMS=#00000001B ; Oscillation mode select register: does not used divider circuit
- Setting of serial interface channel 0  
CSIM0=#10000011B ; 3-wire serial I/O mode, MSB first
- TCL3=#xxxx1001B ; Serial clock  $f_{xx}/2^4$
- P27=1 ; Makes P27 output latch high
- P33 input mode
- Enables serial interface channel 0 interrupt

<Starting>

Set the transmit data to TDATA and call TRANS. After execution has returned from the subroutine, test the busy flag (BUSYFG). If the busy flag is set, transfer has not been executed and therefore, you must execute it again. If the busy flag is cleared, transfer has ended and the receive data has been stored to RDATA.

(2) Example of use

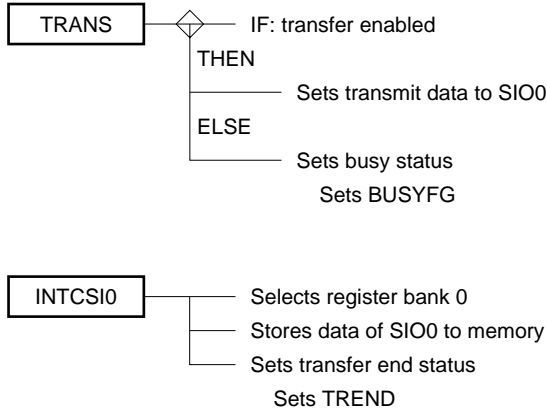


```

EXTRN  TDATA,RDATA,TRANS
EXTBIT  TREND,BUSYFG,BUSY

SCK0    EQU    P2.7
        :
        :
        OSMS=#00000001B      ; Does not use divider circuit
        CSIM0=#10000011B     ; Sets 3-wire serial I/O mode with MSB first
        TCL3=#10011001B     ; Sets SCK0 = 262 kHz
        SET1    SCK0
        SET1    PM3.3        ; Sets P3.3 input mode
        CLR1    CSIMK0       ; Enables serial interface channel 0
        EI
        :
        :
        TDATA=A              ; Sets transmit data
        repeat
            CLR1    BUSYFG    ; Busy test
            CALL    !TRANS
        until_bit(!BUSYFG)
        while_bit(!TREND)    ; Ends transfer
        endw
        A=RDATA              ; Loads receive data
  
```

(3) SPD chart



(4) Program list

```

PUBLIC TRANS, RDATA, TDATA, BUSY, TREND, BUSYFG
VECSI0 CSEG AT 14H
        DW INTCSI0 ; Sets vector address of serial interface channel 0

BUSY EQU 0FF03H.3 ; 0FF03H = PORT3

CSI_DAT DSEG SADDR
RDATA: DS 1 ; Receive data storage area
TDATA: DS 1 ; Transmit data storage area

CSI_FLG BSEG
TREND DBIT ; Sets transfer end status
BUSYFG DBIT ; Sets busy status

CSI_SEG CSEG

;*****
;* INTCSI0 interrupt processing
;*****
INTCSI0:
    SEL RB0
    RDATA=SIO0 (A) ; Stores receive data
    SET1 TREND ; Sets transfer end status
    RETI

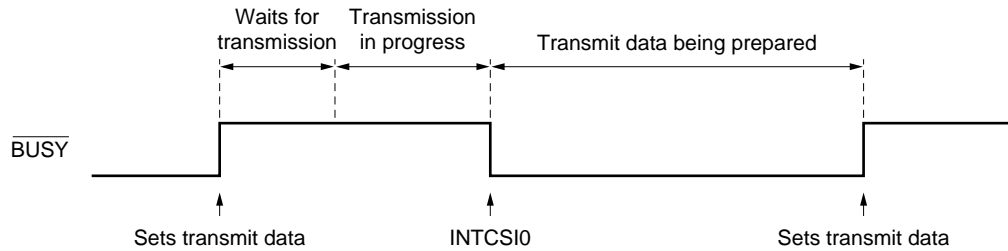
;*****
;* 3-wire (master)
;*****
TRANS:
    if_bit(BUSY)
        SIO0=TDATA (A) ; Enables transfer
    else ; Sets transmit data
        SET1 BUSYFG
    endif ; Sets busy status
    RET
  
```

**8.4.2 Application as slave CPU**

In this example, a slave CPU simultaneously transmits and receives 8-bit data in synchronization with the serial clock from the master CPU. The busy signal output by the slave CPU is low (busy status) while the transmit data is prepared. This busy signal is cleared (high level) when the transmit data is set (CALL !TRANS), and is output (low level) when interrupt INTCSI0 occurs at the end of transfer.

Therefore, the busy status remains after the end of transfer until the data is set.

**Figure 8-38. Output of Busy Signal**



**(1) Description of package**

**<Public declaration symbol>**

- TRANS : Name of 3-wire transfer subroutine of slave
- TDATA : Transmit data storage area
- RDATA : Receive data storage area
- BUSY : Busy signal output port
- TREND : Transfer end test flag

**<Register used>**

- Interrupt : Bank 0, A
- Subroutine : A

**<RAM used>**

| Name  | Usage                | Attribute | Bytes |
|-------|----------------------|-----------|-------|
| TDATA | Stores transmit data | SADDR     | 1     |
| RDATA | Stores receive data  |           |       |

**<Flag used>**

| Name  | Usage                    |
|-------|--------------------------|
| TREND | Sets transfer end status |

**<Nesting>**

2 level 5 bytes

**<Hardware used>**

- Serial interface channel 0
- P33

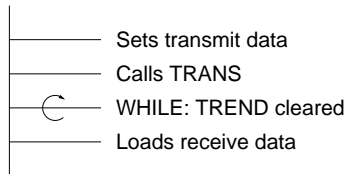
<Initial setting>

- Setting of serial interface channel 0  
     CSIM0=#10000000B ; Sets 3-wire serial I/O mode with MSB first, and inputs external clock
- P33=0 ; P33 output mode
- Setting of busy status
- Enables serial interface channel 0

<Starting>

Set the transmit data to TDATA and call TRANS. Because the busy signal is cleared by the processing of TRANS, the slave waits for communication with the master. After the communication has ended, INTCSI0 occurs and interrupt processing is started. You can check the end of transfer by testing TREND. After TREND has been set, the receive data has been stored to RDATA.

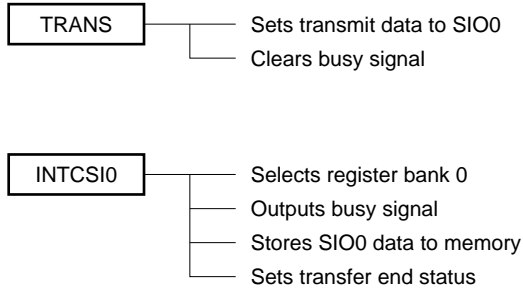
(2) Example of use



```

EXTRN  TDATA,RDATA,TRANS
EXTBIT  TREND,BUSY
      :
      :
CSIM0=#10000000B ; Sets 3-wire I/O mode with MSB first
CLR1  BUSY ; Busy status
CLR1  PM3.3 ; P3.3 output mode
CLR1  CSIMK0 ; Enables serial interface channel 0
EI
      :
      :
TDATA=A ; Sets transmit data
CALL  !TRANS
while_bit(!TREND) ; Ends transfer
endw
A=RDATA ; Loads receive data
  
```

(3) SPD chart



(4) Program list

```

PUBLIC RDATA, TDATA, BUSY, TREND, BUSYFG
PUBLIC TRANS
VECSI0 CSEG AT 14H
        DW INTCSIO ; Sets vector address of serial interface channel 0

CSI_DAT DSEG SADDR
RDATA: DS 1 ; Stores receive data
TRADA: DS 1 ; Stores transmit data

CSI_FLG BSEG
TREND DBIT ; Sets transfer end status
BUSYFG DBIT ; Sets busy status

BUSY EQU 0FF03H.3 ; 0FF03H = PORT3

CSI_SEG CSE
;*****
;* INTCSIO interrupt processing
;*****
INTCSIO:
    SEL RB0
    CLR1 BUSY ; Sets busy status
    RDATA=SI00 (A) ; Stores receive data
    SET1 TREND ; Sets transfer end status
    RETI

;*****
;* 3-wire (slave)
;*****
TRANS:
    SIO0=TDATA (A) ; Sets transmit data
    SET1 BUSY ; Clears busy status
    RET
    
```

## 8.5 Interface in Asynchronous Serial Interface (UART) Mode

Serial interface channel 2 has two modes: asynchronous serial interface (hereafter referred to as “UART”) and 3-wire serial I/O modes.

Serial interface channel 2 is set by the following registers:

- Serial operating mode register 2 (CSIM2)
- Asynchronous serial interface mode register (ASIM)
- Asynchronous serial interface status register (ASIS)
- Baud rate generator control register (BRGC)
- Oscillation mode select register (OSMS)

UART using serial interface channel 2 is briefly described below.

The UART mode of serial interface channel 2 is to transmit or receive 1-byte data following a start bit and can perform full-duplex operation.

The operations of UART communication are described below.

### (a) Communication format

One data frame of transmit/receive data consists of a start bit, character bits, parity bit, and stop bit. The character bit length, parity, and stop bit length in one data frame are specified by using the asynchronous serial interface mode register (ASIM).

### (b) Setting of baud rate

A UART dedicated baud rate generator is provided that can set a wide range of baud rates. A baud rate can also be defined by dividing the clock input to the ASCK pin.

The transmit/receive clock for the baud rate is generated by dividing the main system clock. The baud rate generated from the main system clock can be calculated by the following expression. Table 8-10 shows the relations between the main system clock and baud rate (at  $f_x = 4.19$  MHz).

$$[\text{Baud rate}] = \frac{f_{xx}}{2^n \times (k + 16)} \text{ [Hz]}$$

- Remarks**
1.  $f_{xx}$ : main system clock frequency ( $f_x$  or  $f_x/2$ )
  2.  $f_x$ : main system clock oscillation frequency
  3.  $n$ : value set by TPS0-TPS3  
(bits 4-7 of the baud rate generator control register (BRGC) ( $1 \leq n \leq 11$ ))
  4.  $k$ : value set by MDL0-MDL3 (bits 0-3 of BRGC) ( $0 \leq k \leq 14$ )



**Table 8-10. Relations between Main System Clock and Baud Rate (at  $f_x = 4.19$  MHz)**

| Baud rate (bps) | MCS = 1           |           | MCS = 0           |           |
|-----------------|-------------------|-----------|-------------------|-----------|
|                 | Set value of BRGC | Error (%) | Set value of BRGC | Error (%) |
| 75              | 0BH               | 1.14      | EBH               | 1.14      |
| 110             | 03H               | -2.01     | E3H               | -2.01     |
| 150             | EBH               | 1.14      | DBH               | 1.14      |
| 300             | DBH               | 1.14      | CBH               | 1.14      |
| 600             | CBH               | 1.14      | BBH               | 1.14      |
| 1200            | BBH               | 1.14      | ABH               | 1.14      |
| 2400            | ABH               | 1.14      | 9BH               | 1.14      |
| 4800            | 9BH               | 1.14      | 8BH               | 1.14      |
| 9600            | 8BH               | 1.14      | 7BH               | 1.14      |
| 19200           | 7BH               | 1.14      | 6BH               | 1.14      |
| 31250           | 71H               | -1.31     | 61H               | -1.31     |
| 38400           | 6BH               | 1.14      | 5BH               | 1.14      |
| 76800           | 5BH               | 1.14      | -                 | -         |

★

**Remark** MCS: bit 0 of the oscillation mode select register (OSMS)

**(c) Transmission**

Transmission is started when transmit data has been written to the transmit shift register (TXS). The start bit and parity bit are automatically appended.

**(d) Reception**

Reception is enabled when bit 6 (RXE) of the asynchronous serial interface mode register (ASIM) is set to 1, and the data input to the RxD pin is sampled. When reception of one frame of data has been completed, the receive data in the shift register is transferred to the receive buffer register (RXB) and a receive end interrupt request (INTSR) occurs.

**(e) Receive error**

During reception, three types of errors may occur: parity error, framing error, and overrun error. If the error flag of the asynchronous serial interface status register (ASIS) is set as a result of data reception, a receive error interrupt (INTSER) occurs. By reading the contents of ASIS in the receive error interrupt processing (INTSER), which error has occurred can be identified. The contents of ASIS are reset (0) by either reading the receive buffer register (RXB) or receiving the next data. (if the next data includes an error, that error flag is set).

- Cautions**
1. The contents of the asynchronous serial interface status register (ASIS) are reset to 0 when the receive buffer register (RXB) is read or the next data is received. To determine the nature of the error, be sure to read ASIS before reading RXB.
  2. Be sure to read the receive buffer register (RXB) when a reception error has occurred. Otherwise, an overrun error will occur when the next data is received, and the reception error status will persist.

During communication, transmission and reception with a terminal is performed and  $\overline{\text{RTS}}$  and  $\overline{\text{CTS}}$  are controlled for handshaking. The communication protocol is shown below.

- Baud rate: 9600 bps
- No parity bit
- Stop bit: 2 bits
- LSB first
- $\overline{\text{CTS}}$  input pin: P31
- $\overline{\text{RTS}}$  output pin: P32

When transmission is started, the end of the previous transmission (in which case the transmission end interrupt request flag (STIF) is set to 1) is checked, and transmission is executed if the  $\overline{\text{CTS}}$  input status is ready ("L").

During reception, the busy signal ("H") is output to the  $\overline{\text{RTS}}$  output pin when a reception end interrupt request (INTSR) occurs. "L" is output to the  $\overline{\text{RTS}}$  output pin when reception is enabled.

A receive error interrupt request (INTSER) occurs if a receive error (parity error, framing error, or overrun error) occurs, and the error flag is set. Figure 8-39 shows a communication block diagram, and Figures 8-40 and 8-41 show the transmission/reception format.

**Figure 8-39. Communication Block Diagram**

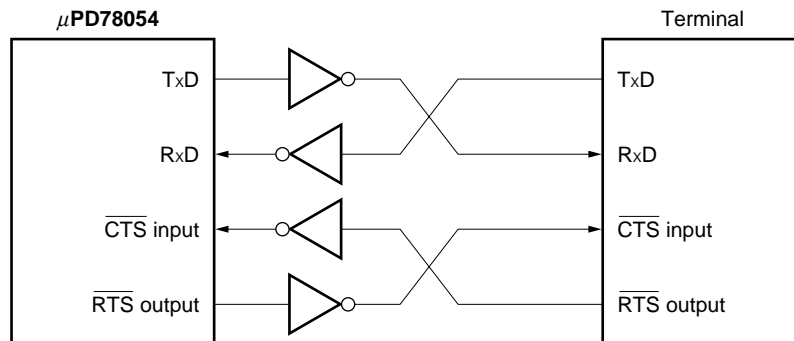


Figure 8-40. Communication Format

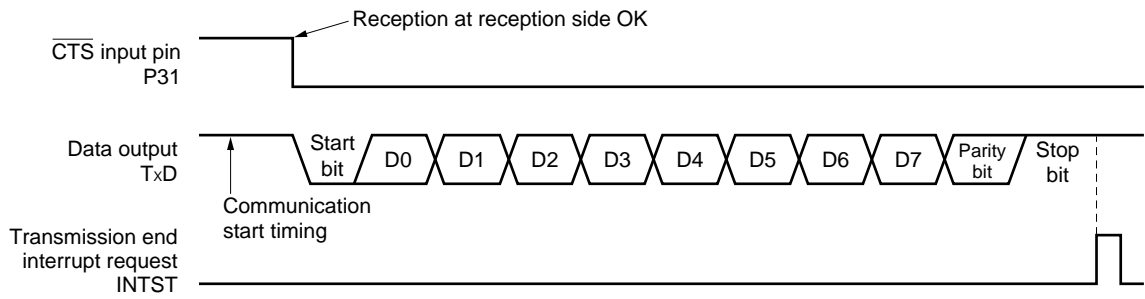
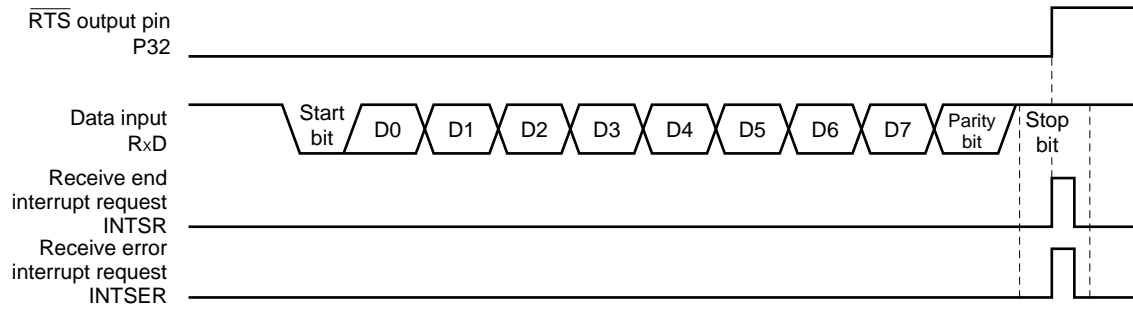


Figure 8-41. Reception Format



**(1) Description of package****<Public declaration symbol>**

- Subroutine name  
S\_SOSHIN : Transmit routine
- Input parameter of S\_SOSHIN routine  
SOSHIN : Transmit data storage area
- Output parameter of S\_SOSHIN routine  
F\_BUSY : Transmit busy flag
- Output parameter of INTSR interrupt  
JUSHIN : Receive data storage area  
F\_TUSHIN : Reception end flag
- Output parameter of INTSER interrupt  
F\_ERR : Receive error flag

**<Register used>**

S\_SOSHIN : Bank 0, A  
 INTSR : Bank 3, A  
 INTSER : Bank 3, A

**<RAM used>**

| Name   | Usage                      | Attribute | Bytes |
|--------|----------------------------|-----------|-------|
| SOSHIN | Transmit data storage area | SADDR     | 1     |
| JUSHIN | Receive data storage area  | SADDR     | 1     |

**<Flag used>**

| Name     | Usage  |
|----------|--|
| F_TUSHIN | Set at end of reception  |
| F_BUSY   | Set if transmission cannot be started by $\overline{\text{CTS}}$ input pin; cleared if transmission can be started |
| F_ERR    | Set if receive error occurs  |

**<Nesting level>**

2 levels 5 bytes

**<Hardware used>**

- Serial interface channel 2 (UART mode)

**<Initial setting>**

- OSMS=#00000001B ; Oscillation mode select register: does not use divider circuit
- CLR1 P3.2 ; P31 =  $\overline{\text{CTS}}$  input, P32 =  $\overline{\text{RTS}}$  output  
PM3=#xxxx10xB
- BRGC=#10001011B ; Sets baud rate to 9600 bps (error: 1.14%)
- CSIM2=#00000000B ; Sets 0 to serial operation mode register 2 when UART is used
- ASIM=#11001101B ; Sets asynchronous serial interface mode register
- CLR1 SRIF ; Clears reception end receive error interrupt request flags  
CLR1 SERIF
- SET1 STIF ; Sets transmission end interrupt request flag (to end transmission)
- CLR1 SRMK ; Enables reception end and receive error interrupts  
CLR1 SERMK

**Caution** Before starting transmission, check the transmission end interrupt request flag (STIF) so that transmission is not executed during transmission. Therefore, set the transmission end interrupt request flag (STIF) after reset and start.

**Remark** To use the transmission end interrupt (to generate the interrupt request), use an additional flag. Set the additional flag as the initial setting. Clear the flag at the start of transmission, and set it in the interrupt processing.

**<Starting>**

Store the transmit data to the SOSHIN area at the start of transmission and call the S\_SOSHIN routine.

(2) Example of use

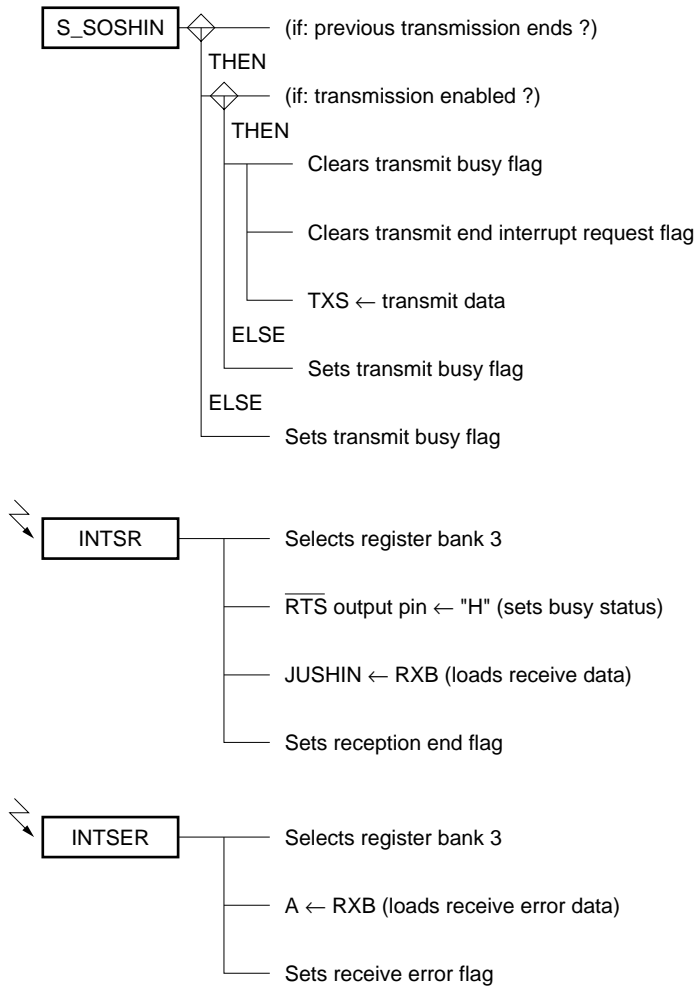
```

EXTRN  S_SOSHIN
EXTRN  SOSHIN, JUSHIN
EXTBIT  F_TUSHIN, F_ERR, F_BUSY
;
RTS_0   EQU    P3.2           ; RTS output port
;
OSMS=#00000001B             ; Does not use divider circuit
CLR1    RTS_0                 ;
PM3=#11111011B             ; P31 = CTS input, P32 = RTS output
BRGC=#10001011B           ; 9600 bps (error: 1.41%)
CSIM2=#00000000B          ; Initial setting when UART is used
ASIM=#11001101B           ; Enables receive error interrupt. Stop bit: 2 bits
; Transmit data: 8 bits. No parity. Enables reception and transmission.

CLR1    SERIF                 ; Clears receive error interrupt request flag
CLR1    SRIF                  ; Clears reception end interrupt request flag
SET1    STIF                  ; Sets transmit end interrupt request flag
;                               ; →Ends transmission
CLR1    SERMK                 ; Enables receive error interrupt
CLR1    SRMK                  ; Enables reception end interrupt
EI
;
;
;
if_bit(transmission request) ; Sets transmission request flag?
    SOSHIN=A                 ; Stores transmit data
    CALL    !S_SOSHIN        ; Calls transmit routine
endif
if_bit(F_BUSY)               ; End of transmission?
    .
    Communication busy processing;
    .
endif
;
;
if_bit(F_TUSHIN)             ; Sets reception end flag?
    CLR1    F_TUSHIN         ; Clears reception end flag
    A=JUSHIN                 ; Reads receive data
    .
    Reception processing    ;
    .
    CLR1    RTS_0           ; RTS output pin ← "L" (ready status)
endif
;
;
if_bit(F_ERR)                ; Receive error occurs?
    CLR1    F_ERR           ;
    .
    Receive error processing ;
    .
endif
;
;

```

(3) SPD chart



## (4) Program list

```

PUBLIC  S_SOSHIN
PUBLIC  SOSHIN, JUSHIN
PUBLIC  F_TUSHIN, F_ERR, F_BUSY
;
VESR    CSEG    AT 1AH
        DW      INTSR
VESER   CSEG    AT 18H
        DW      INTSER
;
RTS_0   EQU     P3.2           ; RTS output port
CTS_I   EQU     P3.1           ; CTS input port
;
UARTRAM DSEG    SADDR
SOSHIN: DS     1               ; Transmit data storage area
JUSHIN: DS     1               ; Receive data storage area
;
UARTFLG BSEG
F_TUSHIN DBIT                ; Reception end flag
F_BUSY   DBIT                ; Communication busy flag
F_ERR    DBIT                ; Reception error flag
;
;*****
;      Transmission routine
;*****
UARTPRO  CSEG
S_SOSHIN:
    if_bit(STIF)                ; Previous transmission end?
        if_bit(!CTS_I)          ; Enables transmission?
            CLR1  STIF           ; Clears transmit end interrupt request flag
            TXS=SOSHIN (A)       ; Stores transmit data
            CLR1  F_BUSY        ; Clears transmit busy flag
        else
            SET1  F_BUSY        ; Disables transmission → sets transmission busy flag
        endif
    else
        SET1  F_BUSY
    endif
    RET
;*****
;      Reception end routine
;*****
INTSR:
    SEL    RB3                  ; RTS ← H
    SET1  RTS_0                 ; Loads receive data
    JUSHIN=RXB (A)              ; Sets reception end flag
    SET1  F_TUSHIN
    RETI
;*****
;      Reception error routine
;*****
INTSER:
    SEL    RB3                  ; Selects bank 3
    A=RXB                        ; Reads error data
    SET1  F_ERR                  ; Sets receive error flag
    RETI
END

```



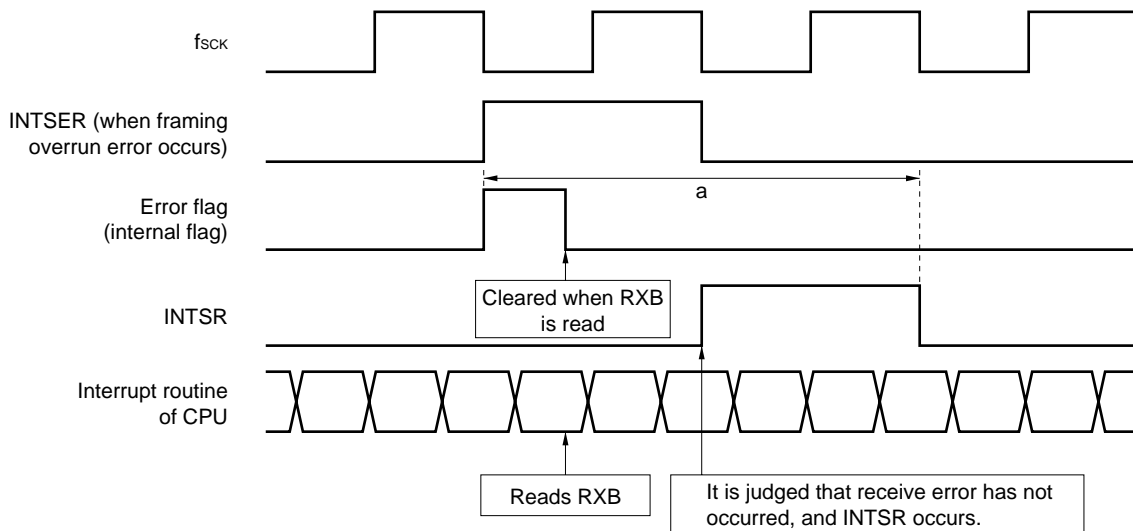
**(f) Limitation when using UART mode**

In the UART mode, the reception completion interrupt (INTSR) occurs a certain time after the reception error interrupt (INTSER) has occurred and cleared. As a result, the following phenomenon may take place.

- **Description**

If bit 1 (ISRM) of the asynchronous serial interface mode register (ASIM) is set to 1, the reception completion interrupt (INTSR) does not occur when a reception error occurs. If the receive buffer register (RXB) is read at certain timing (a in Figure 8-42) during reception error interrupt (INTSER) processing, the internal error flag is cleared to 0. Therefore, it is judged that a reception error has not occurred, and INTSR, which should not occur, occurs. Figure 8-42 illustrates this operation.

**Figure 8-42. Timing of Reception Completion Interrupt (when ISRM = 1)**



**Remark** ISRM : Bit 1 of asynchronous serial interface mode register (ASIM)

f<sub>sck</sub> : Source clock of 5-bit counter of baud rate generator

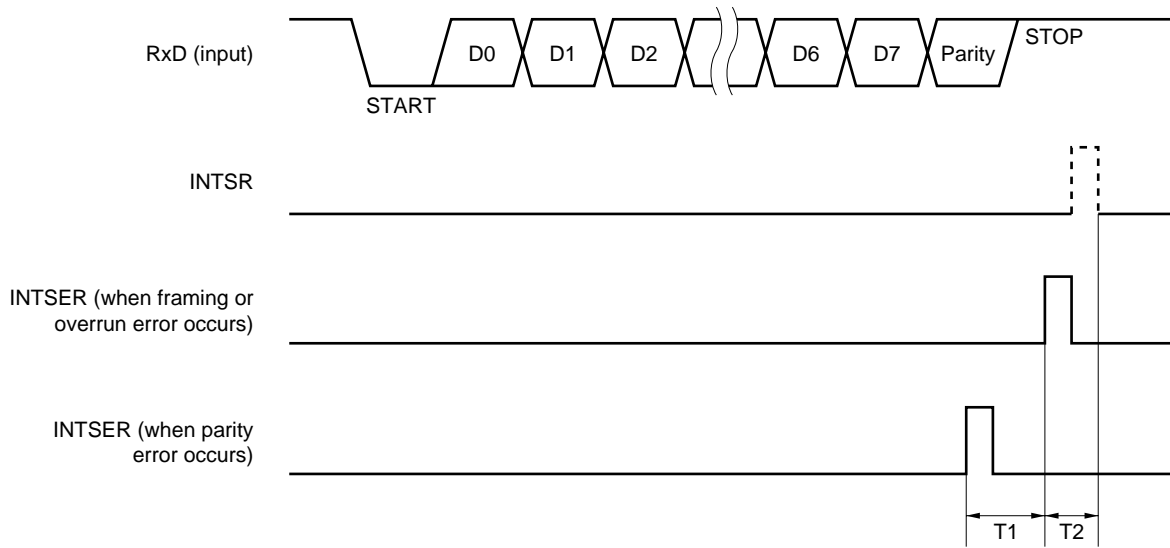
RXB : Receive buffer register

To prevent this phenomenon, take the following measures:

- **Preventive measures**

- In case of framing error or overrun error  
Disable the receive buffer register (RXB) from being read for a certain period (T<sub>2</sub> in Figure 8-43) after the receive error interrupt (INTSER) has occurred.
- In case of parity error  
Disable the receive buffer register (RXB) from being read for a certain period (T<sub>1</sub> + T<sub>2</sub> in Figure 8-43) after the reception error interrupt (INTSER) has occurred.

Figure 8-43. Receive Buffer Register Reading Disabled Period



T1: Time of one data of baud rate selected by baud rate generator control register (BRGC) (1/baud rate)

T2: Time of two source clocks ( $f_{sck}$ ) of 5-bit counter selected by BRGC

• **Example of preventive measures**

An example of preventive measures is shown below.

**[Condition]**

$f_x = 5.0 \text{ MHz}$

Processor clock control register (PCC) = 00H

Oscillation mode select register (OSMS) = 01H

Baud rate generator control register (BRGC) = 80H (2400 bps is selected as baud rate)

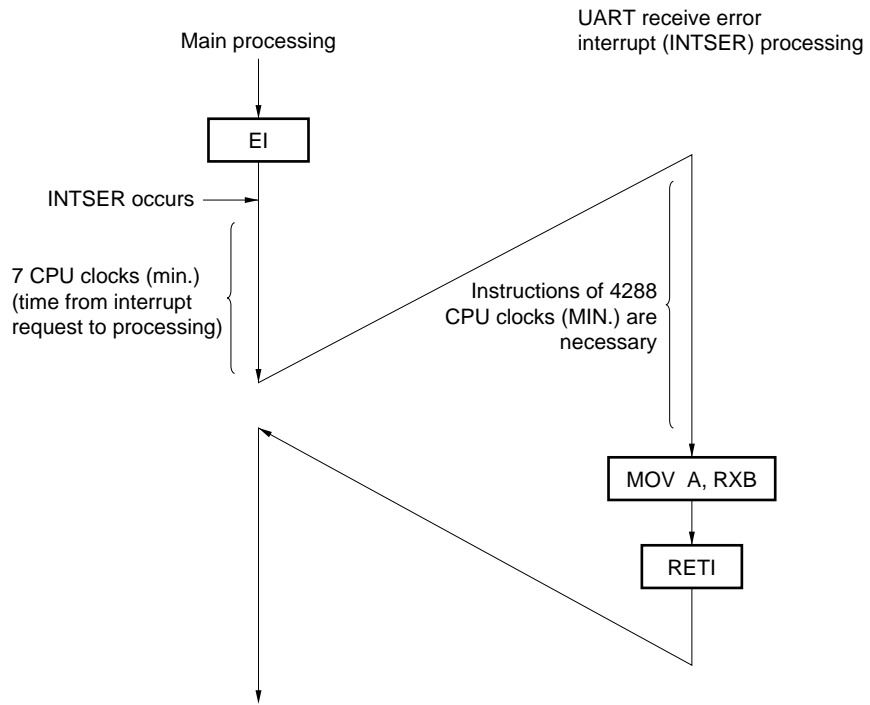
$t_{CY} = 0.4 \mu\text{s}$  ( $t_{CY} = 0.2 \mu\text{s}$ )

$$T1 = \frac{1}{2400} = 833.4 \mu\text{s}$$

$$T2 = 12.8 \times 2 = 25.6 \mu\text{s}$$

$$\frac{T1 + T2}{t_{CY}} = 4295 \text{ (clocks)}$$

[Example]



[MEMO]

## CHAPTER 9 APPLICATIONS OF A/D CONVERTER

The A/D converter of the 78K/0 series is a successive approximation type with an 8-bit resolution and eight channels. Although only a select mode is supported as the operation mode, conversion can be started by an external trigger. If the external trigger is not used, the analog data of a selected channel is repeatedly converted into a digital signal.

The A/D converter is set by the A/D converter mode register (ADM), A/D converter input select register (ADIS), external interrupt mode register 1 (INTM1), and A/D current cut select register (IEAD).

**Caution** IEAD is provided only to the  $\mu$ PD78098 and 78098B subseries.

**Figure 9-1. Format of A/D Converter Mode Register**

( $\mu$ PD78054, 78054Y, 78064, 78064Y, 78078, 78078Y, 78083, 780058, 780058Y, 780308, 780308Y, 78058F, 78058FY, 78064B, 78075B, 78075BY subseries,  $\mu$ PD78070A, 78070AY)

|        |    |     |     |     |      |      |      |     |         |          |     |
|--------|----|-----|-----|-----|------|------|------|-----|---------|----------|-----|
| Symbol | 7  | 6   | 5   | 4   | 3    | 2    | 1    | 0   | Address | At reset | R/W |
| ADM    | CS | TRG | FR1 | FR0 | ADM3 | ADM2 | ADM1 | HSC | FF80H   | 01H      | R/W |

| ADM3 | ADM2 | ADM1 | Selects analog input channel |
|------|------|------|------------------------------|
| 0    | 0    | 0    | ANI0                         |
| 0    | 0    | 1    | ANI1                         |
| 0    | 1    | 0    | ANI2                         |
| 0    | 1    | 1    | ANI3                         |
| 1    | 0    | 0    | ANI4                         |
| 1    | 0    | 1    | ANI5                         |
| 1    | 1    | 0    | ANI6                         |
| 1    | 1    | 1    | ANI7                         |

| FR1    | FR0 | HSC | Selects A/D conversion time <sup>Note 1</sup>    |  |  |                           |
|--------|-----|-----|--|--|--|---------------------------|
|        |     |     | At $f_x = 5.0$ MHz                               |  | At $f_x = 4.19$ MHz                              |                           |
|        |     |     | MCS = 1  | MCS = 0  | MCS = 1  | MCS = 0                   |
| 0      | 0   | 1   | 80/ $f_x$ (setting prohibited) <sup>Note 2</sup> | 160/ $f_x$ (32.0 $\mu$ s)                        | 80/ $f_x$ (19.1 $\mu$ s)                         | 160/ $f_x$ (38.1 $\mu$ s) |
| 0      | 1   | 1   | 40/ $f_x$ (setting prohibited) <sup>Note 2</sup> | 80/ $f_x$ (setting prohibited) <sup>Note 2</sup> | 40/ $f_x$ (setting prohibited) <sup>Note 2</sup> | 80/ $f_x$ (19.1 $\mu$ s)  |
| 1      | 0   | 0   | 50/ $f_x$ (setting prohibited) <sup>Note 2</sup> | 100/ $f_x$ (20.0 $\mu$ s)                        | 50/ $f_x$ (setting prohibited) <sup>Note 2</sup> | 100/ $f_x$ (23.8 $\mu$ s) |
| 1      | 0   | 1   | 100/ $f_x$ (20.0 $\mu$ s)                        | 200/ $f_x$ (40.0 $\mu$ s)                        | 100/ $f_x$ (23.8 $\mu$ s)                        | 200/ $f_x$ (47.7 $\mu$ s) |
| Others |     |     | Setting prohibited                               |  |  |                           |

| TRG | Selects external trigger                                |
|-----|---|
| 0   | No external trigger (software start)                    |
| 1   | Conversion started by external trigger (hardware start) |

| CS | Controls A/D conversion operation |
|----|-----------------------------------|
| 0  | Stops operation                   |
| 1  | Starts operation                  |

**Notes 1.** Set the A/D conversion time to 19.1  $\mu$ s or longer.

**2.** These settings are prohibited because the A/D conversion time is less than 19.1  $\mu$ s.

**Cautions 1.** To reduce the power consumption of the A/D converter when the standby function is used, stop the A/D conversion operation by clearing bit 7 (CS) to 0, and then execute the HALT or STOP instruction.

**2.** To resume the A/D conversion operation which has been once stopped, clear the interrupt request flag (ADIF) to 0 and then start the A/D conversion operation.

**Remarks 1.**  $f_x$  : main system clock oscillation frequency

**2.** MCS : bit 0 of the oscillation mode select register (OSMS)

Figure 9-2. Format of A/D Converter Mode Register ( $\mu$ PD78098, 78098B subseries)

|        |    |     |     |     |      |      |      |     |         |          |     |
|--------|----|-----|-----|-----|------|------|------|-----|---------|----------|-----|
| Symbol | 7  | 6   | 5   | 4   | 3    | 2    | 1    | 0   | Address | At reset | R/W |
| ADM    | CS | TRG | FR1 | FR0 | ADM3 | ADM2 | ADM1 | HSC | FF80H   | 01H      | R/W |

| ADM3 | ADM2 | ADM1 | Selects analog input channel |
|------|------|------|------------------------------|
| 0    | 0    | 0    | ANI0                         |
| 0    | 0    | 1    | ANI1                         |
| 0    | 1    | 0    | ANI2                         |
| 0    | 1    | 1    | ANI3                         |
| 1    | 0    | 0    | ANI4                         |
| 1    | 0    | 1    | ANI5                         |
| 1    | 1    | 0    | ANI6                         |
| 1    | 1    | 1    | ANI7                         |

| FR1    | FR0 | HSC | Selects A/D conversion time <sup>Note 1</sup>             |
|--------|-----|-----|---|
| 0      | 0   | 1   | 80/f <sub>xx</sub> (20.0 $\mu$ s)                         |
| 0      | 1   | 1   | 40/f <sub>xx</sub> (setting prohibited) <sup>Note 2</sup> |
| 1      | 0   | 0   | 50/f <sub>xx</sub> (setting prohibited) <sup>Note 2</sup> |
| 1      | 0   | 1   | 100/f <sub>xx</sub> (25.0 $\mu$ s)                        |
| Others |     |     | Setting prohibited  |

| TRG | Selects external trigger                                |
|-----|---|
| 0   | No external trigger (software start)                    |
| 1   | Conversion started by external trigger (hardware start) |

| CS | Controls A/D conversion operation |
|----|-----------------------------------|
| 0  | Stops operation                   |
| 1  | Starts operation                  |

- Notes**
1. Set the A/D conversion time to 19.1  $\mu$ s or longer.
  2. These settings are prohibited because the A/D conversion time is less than 19.1  $\mu$ s.

- Cautions**
1. To reduce the power consumption of the A/D converter when the standby function is used, stop the A/D conversion operation by clearing bit 7 (CS) to 0, and then execute the HALT or STOP instruction.
  2. To resume the A/D conversion operation which has been once stopped, clear the interrupt request flag (ADIF) to 0 and then start the A/D conversion operation.

- Remarks**
1. f<sub>xx</sub> : main system clock frequency
  2. ( ) : f<sub>xx</sub> = 4.0 MHz



Figure 9-3. Format of A/D Converter Mode Register ( $\mu$ PD780018, 780018Y subseries)

|        |    |     |     |     |      |      |      |     |         |          |     |
|--------|----|-----|-----|-----|------|------|------|-----|---------|----------|-----|
| Symbol | 7  | 6   | 5   | 4   | 3    | 2    | 1    | 0   | Address | At reset | R/W |
| ADM    | CS | TRG | FR1 | FR0 | ADM3 | ADM2 | ADM1 | HSC | FF80H   | 01H      | R/W |

| ADM3 | ADM2 | ADM1 | Selects analog input channel |
|------|------|------|------------------------------|
| 0    | 0    | 0    | ANI0                         |
| 0    | 0    | 1    | ANI1                         |
| 0    | 1    | 0    | ANI2                         |
| 0    | 1    | 1    | ANI3                         |
| 1    | 0    | 0    | ANI4                         |
| 1    | 0    | 1    | ANI5                         |
| 1    | 1    | 0    | ANI6                         |
| 1    | 1    | 1    | ANI7                         |

| FR1    | FR0 | HSC | Selects A/D conversion time <sup>Note 1</sup>    |  |
|--------|-----|-----|--|--|
|        |     |     | At $f_x = 5.0$ MHz                               | At $f_x = 4.19$ MHz                              |
| 0      | 0   | 1   | 80/ $f_x$ (setting prohibited) <sup>Note 2</sup> | 80/ $f_x$ (19.1 $\mu$ s)                         |
| 0      | 1   | 1   | 40/ $f_x$ (setting prohibited) <sup>Note 2</sup> | 40/ $f_x$ (setting prohibited) <sup>Note 2</sup> |
| 1      | 0   | 0   | 50/ $f_x$ (setting prohibited) <sup>Note 2</sup> | 50/ $f_x$ (setting prohibited) <sup>Note 2</sup> |
| 1      | 0   | 1   | 100/ $f_x$ (20.0 $\mu$ s)                        |  |
| Others |     |     | Setting prohibited                               |  |

| TRG | Selects external trigger                                |
|-----|---|
| 0   | No external trigger (software start)                    |
| 1   | Conversion started by external trigger (hardware start) |

| CS | Controls A/D conversion operation |
|----|-----------------------------------|
| 0  | Stops operation                   |
| 1  | Starts operation                  |

- Notes**
1. Set the A/D conversion time to 19.1  $\mu$ s or longer.
  2. These settings are prohibited because the A/D conversion time is less than 19.1  $\mu$ s.

- Cautions**
1. To reduce the power consumption of the A/D converter when the standby function is used, stop the A/D conversion operation by clearing bit 7 (CS) to 0, and then execute the HALT or STOP instruction.
  2. To resume the A/D conversion operation which has been once stopped, clear the interrupt request flag (ADIF) to 0 and then start the A/D conversion operation.

**Remark**  $f_x$  : main system clock oscillation frequency



Figure 9-4. Format of A/D Converter Input Select Register

|        |   |   |   |   |       |       |       |       |         |          |     |
|--------|---|---|---|---|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7 | 6 | 5 | 4 | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| ADIS   | 0 | 0 | 0 | 0 | ADIS3 | ADIS2 | ADIS1 | ADIS0 | FF84H   | 00H      | R/W |

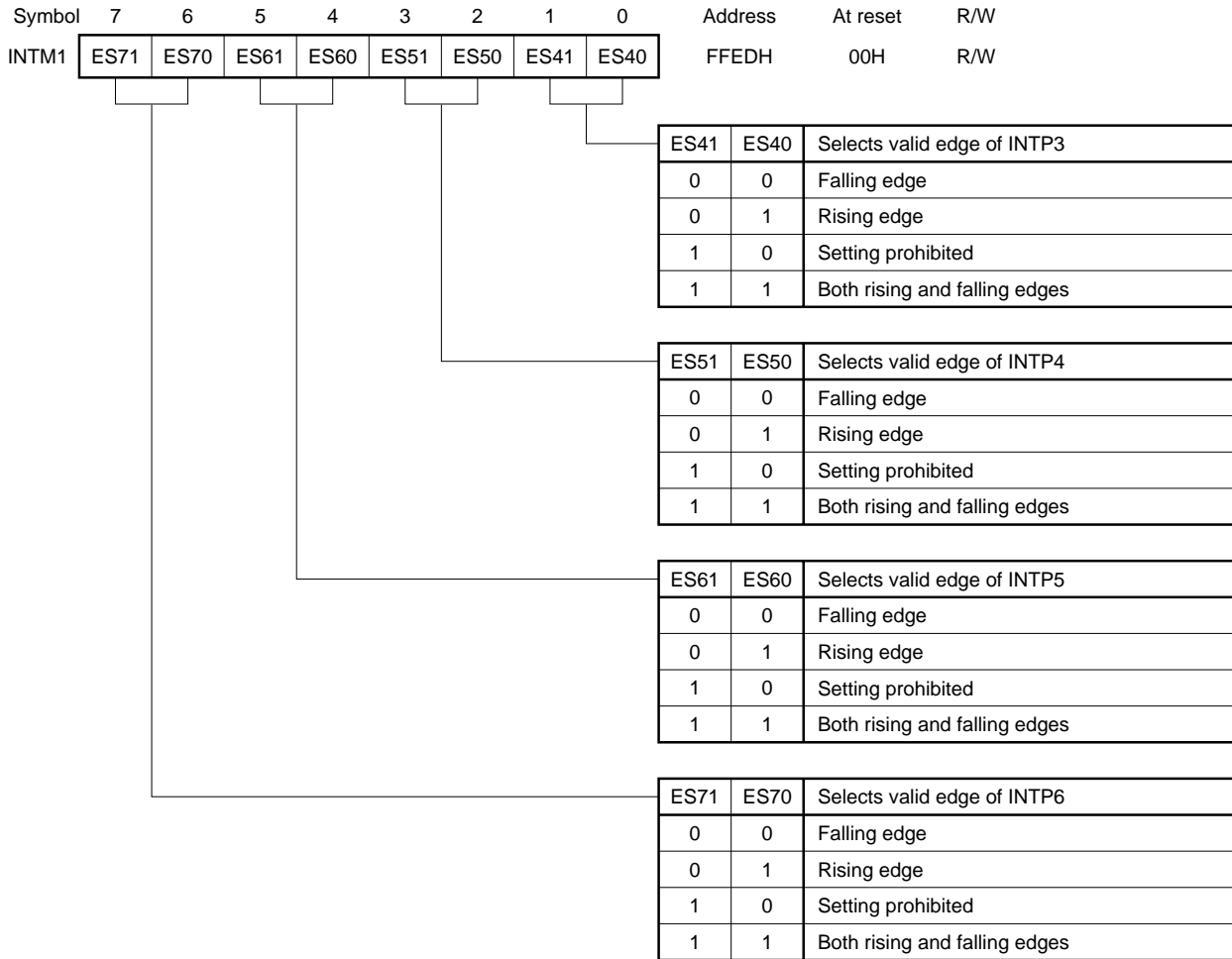
  

| ADIS3  | ADIS2 | ADIS1 | ADIS0 | Selects number of analog input channels |
|--------|-------|-------|-------|---|
| 0      | 0     | 0     | 0     | No analog input channel (P10-P17)       |
| 0      | 0     | 0     | 1     | 1 channel (ANI0, P11-P17)               |
| 0      | 0     | 1     | 0     | 2 channels (ANI0, ANI1, P12-P17)        |
| 0      | 0     | 1     | 1     | 3 channels (ANI0-ANI2, P13-P17)         |
| 0      | 1     | 0     | 0     | 4 channels (ANI0-ANI3, P14-P17)         |
| 0      | 1     | 0     | 1     | 5 channels (ANI0-ANI4, P15-P17)         |
| 0      | 1     | 1     | 0     | 6 channels (ANI0-ANI5, P16-P17)         |
| 0      | 1     | 1     | 1     | 7 channels (ANI0-ANI6, P17)             |
| 1      | 0     | 0     | 0     | 8 channels (ANI0-ANI7)                  |
| Others |       |       |       | Setting prohibited                      |

**Cautions 1. Set analog input channels in the following steps:**

- <1> Set the number of analog input channels by using ADIS.
  - <2> Select one channel whose data is to be converted, from the channels selected by ADIS, by using the A/D converter mode register (ADM).
2. The internal pull-up resistor is not used to the channel selected by ADIS as an analog input channel, regardless of the value of the bit 1 (PUO1) of the pull-up resistor option register L (PUOL).

**Figure 9-5. Format of External Interrupt Mode Register 1**  
 (μPD78054, 78054Y, 78078, 78078Y, 78098, 780018, 780018Y, 78058F,  
 78058FY, 78075B, 78075BY, 78098B subseries, μPD78070A, 78070AY)



**Figure 9-6. Format of External Interrupt Mode Register 1**

( $\mu$ PD78064, 78064Y, 780058, 780058Y, 780308, 780308Y, 78064B subseries)

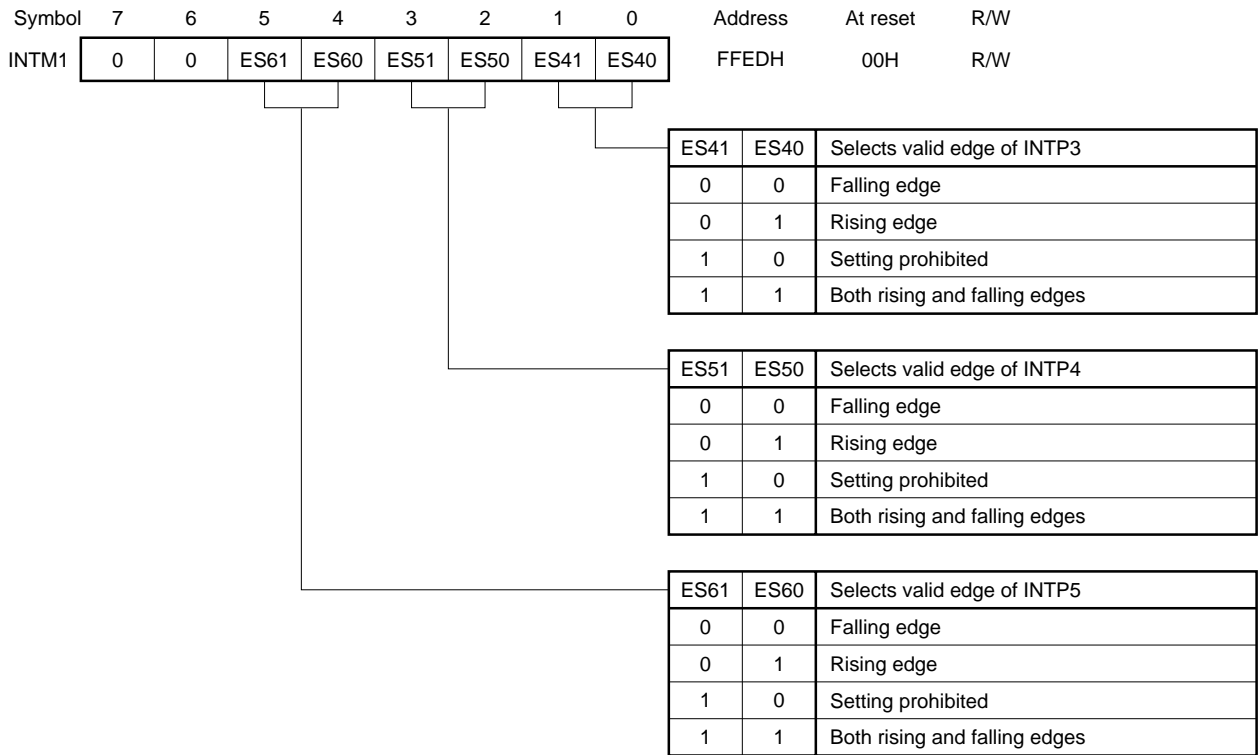
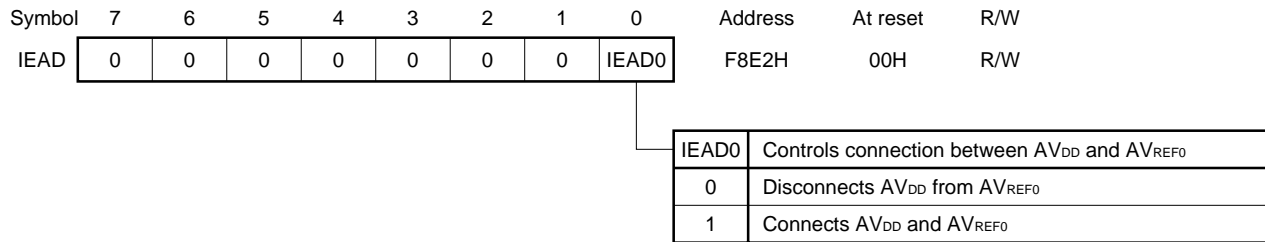


Figure 9-7. Format of External Interrupt Mode Register 1 ( $\mu$ PD78083 subseries)



**Caution** Be sure to clear bits 2 through 7 to 0.

Figure 9-8. Format of A/D Current Cut Select Register ( $\mu$ PD78098, 78098B subseries)



### 9.1 Level Meter

In this application example, the analog voltage input to the A/D converter is displayed on an LED matrix consisting of  $4 \times 4$ , i.e., 16 LEDs.

Because a level meter has been included in this example, the LED display is given in decibel units. Figure 9-9 shows the circuit of the level meter, and Figure 9-10 shows the relations between the result of the A/D conversion and the number of display digits.

Figure 9-9. Example of Level Meter Circuit

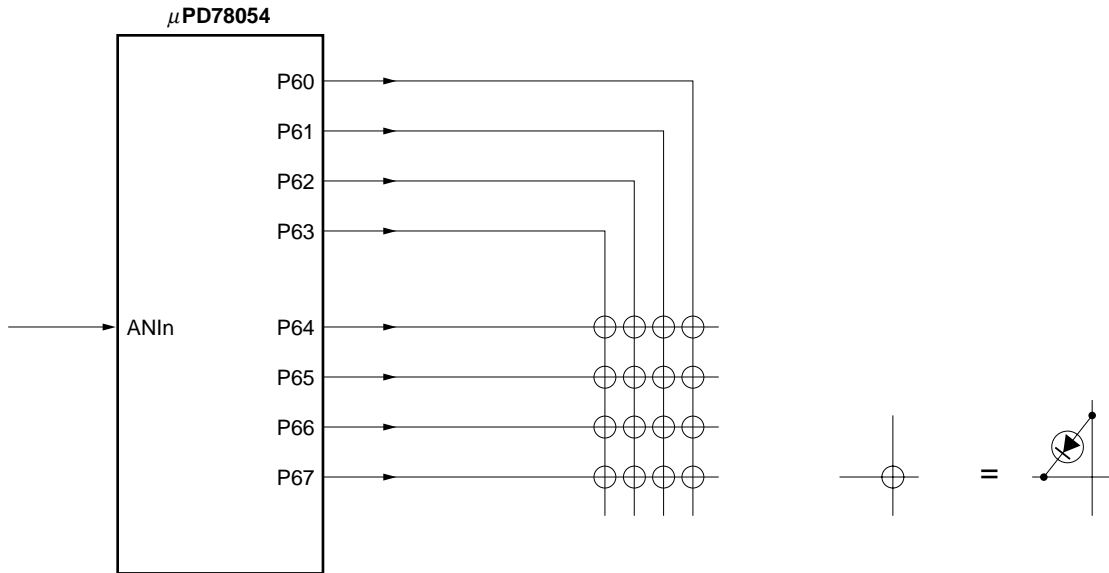
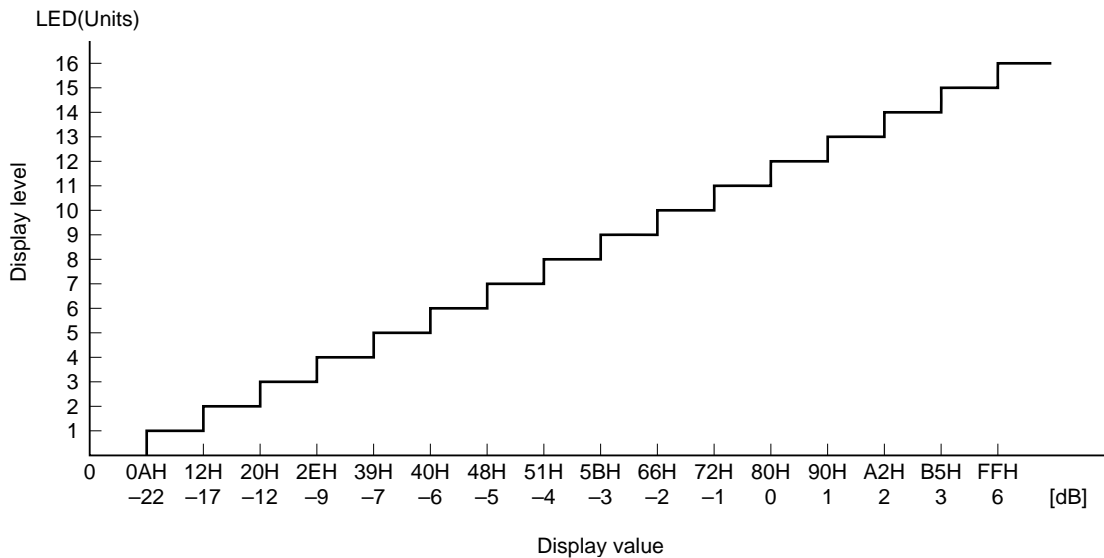


Figure 9-10. A/D Conversion Result and Display



The level meter in this example operates with specifications <1> through <3> below.

**<1> Measurement method**

A/D conversion is performed every 20 ms, and the average value of four previous data is calculated and displayed on the LEDs.

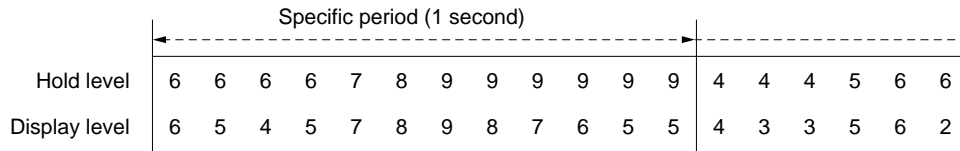
**<2> Display method**

The LED display is updated every 20 ms. The LED matrix consists of  $4 \times 4 = 16$  LEDs and performs dynamic display. For the dynamic display, 8-bit timer/event counter 1 (interval time: 2 ms) is used.

**<3> Peak hold**

Holding the maximum display level for a specific period (1 second) is called peak hold. Even if the display level drops during a specific period, only the LED at the maximum display level is held. Therefore, the hold period of the hold level is 20 ms to 1 s.

**Figure 9-11. Concept of Peak Hold**



**(1) Description of package**

**<Public declaration symbol>**

- LEVEL : Name of LED display subroutine
- DSPLEV : Display level storage area
- HLDLEV : Hold level storage area
- CT20MS : Counter measuring 20 ms
- CT1S : Counter measuring 1 s

**<Register used>**

- AX, HL, BC (subroutine processing)
- Bank 0: A, HL, B (interrupt processing)

**<RAM used>**

| Name   | Usage                            | Attribute | Bytes |
|--------|----------------------------------|-----------|-------|
| ADDAT  | Stores A/D conversion value      | SADDR     | 4     |
| DSPLEV | Stores display level             |           | 1     |
| HLDLEV | Stores hold level                |           |       |
| CT20MS | Counter measuring 20 ms          |           |       |
| CT1S   | Counter measuring 1 s            |           |       |
| DIGCNT | Display digit counter            |           |       |
| DSPDAT | Stores display data              |           | 4     |
| WORKCT | Work counter for loop processing |           | 1     |

**<Flag used>**

| Name   | Usage           |
|--------|-----------------|
| T20MSF | Set every 20 ms |
| T1SF   | Set every 1 s   |

**<Nesting>**

2 levels 5 bytes

**<Hardware used>**

- A/D converter
- 8-bit timer/event counter 1
- P6

**<Initial setting>**

- OSMS = #00000001B ; Oscillation mode select register: does not use divider circuit
- ADM = #1000xxx1B ; Selects channel of A/D converter and starts operation
- TCL1 = #10111011B ; Interval time of 2 ms of 8-bit timer/event counter 1  
TMC1 = #00000001B  
CR10 = 130
- P6 output mode
- Makes P6 output latch low
- Enables INTTM1 interrupt

**<Starting>**

This program performs two types of processing: A/D conversion (subroutine) and LED display (interrupt).

- A/D conversion processing

Call LEVEL at least once every 20 ms from the main processing. The LEVEL processing performs A/D conversion processing only when 20 has elapsed.

- LED display

The 4 × 4 LED matrix performs dynamic display by using the interrupt processing of 8-bit timer/event counter 1 (interval: 2 ms). The interrupt processing of 8-bit timer/event counter 1 sets the T20MSF (loading of A/D conversion value) and T1SF (end of hold period) used for the A/D conversion processing at an interval of 2 ms.

**(2) Example of use**

```

EXTRN    LEVEL, CT20MS, CT1S

MOV      CT20MS, #10
MOV      CT1S, #50
MOV      TMC2, #00100110B
CLR1     TMMK3                ; Turns OFF LED display

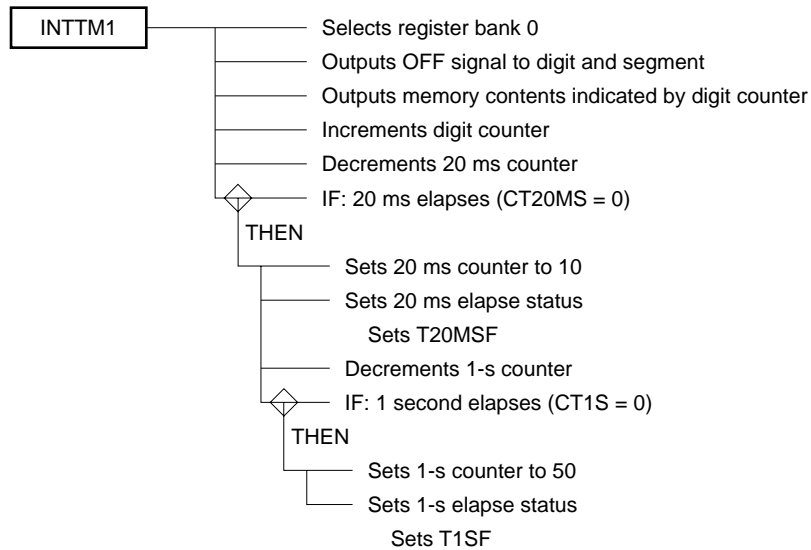
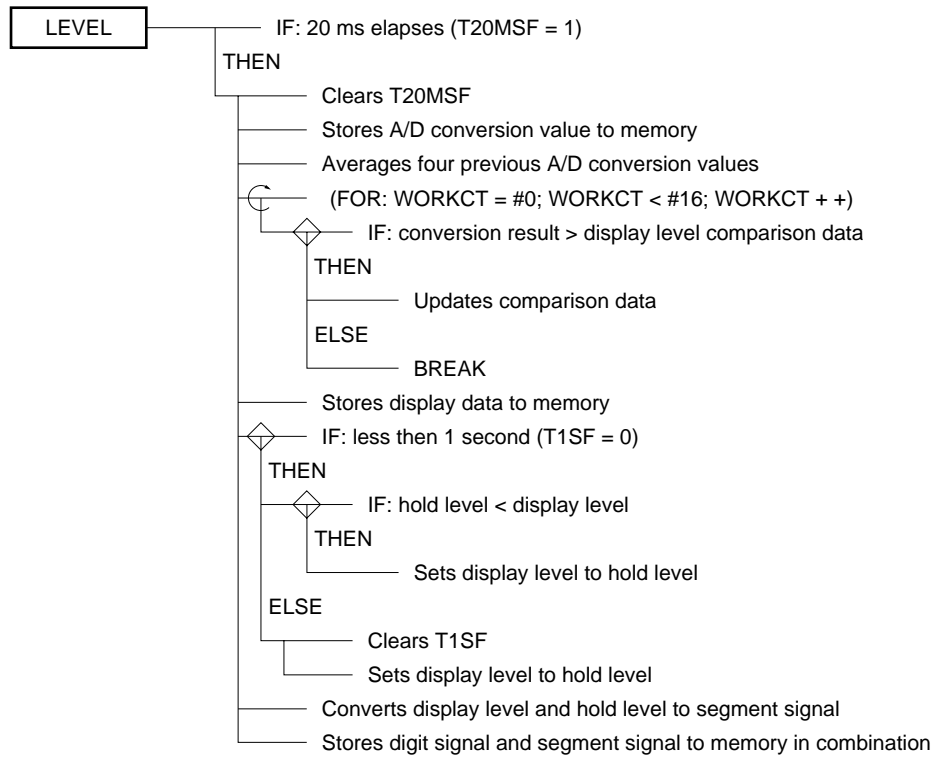
P6=#00H
PM6=#00000000B              ; Does not use divider circuit
OSMS=#00000001B            ; ANI0 pin starts operation
ADM=#10000001B             ; Sets 8-bit timer/event counter 1 to 2 ms
TCL1=#10111011B

CR10=#130
TMC1=#00000001B            ; Enables 8-bit timer/event counter 1 interrupt
CLR1     TMMK1
EI

```



(3) SPD chart



(4) Program list

```

PUBLIC LEVEL, HLDLEV, DSPLEV, CT20MS, CT1S

AD_DAT DSEG SADDR
ADDAT: DS 4 ; A/D conversion result storage area
DSPLEV: DS 1 ; Display level value
HLDLEV: DS 1 ; Hold level value
CT20MS: DS 1 ; 20 ms counter
CT1S: DS 1 ; 1 s counter
DIGCNT: DS 1 ; Display digit counter
DSPDAT: DS 4 ; Display data
WORKCT: DS 1

AD_FLG BSEG
T20MSF DBIT ; Measures 20 ms
T1SF DBIT ; Measures 1 s

VETM1 CSEG AT 24H
DW INTTM1 ; Sets vector address of 8-bit timer/event counter 1

AD_SEG CSEG
;*****
* Sets level meter data
;*****
LEVEL:
IF_BIT(T20MSF) ; Checks 20 ms
CLR1 T20MSF
A=ADCR ; Inputs A/D conversion value
A<->ADDAT ; Stores A/D conversion value
A<->ADDAT+1
A<->ADDAT+2
A<->ADDAT+3
; Averages four A/D conversion values
AX=#0H
HL=#ADDAT ; Data storage address
for(WORKCT=#0;WORKCT<#4;WORKCT++)
A+=[HL]
HL++
if_bit(CY) ; Carry
X++ ; Higher digit
endif
next

A<->X
C=#4 ; Averages four values
AX/=C ; AX/C = AX (quotient) ... C (remainder)
if(C>=#2) (A) ; Remainder processing (2 or higher is carried)
X++ ; Carry processing
endif

HL=#LEVTBL
B=#0 ; Conversion result storage register
for(WORKCT=#0;WORKCT<#16;WORKCT++)
if(X>=[HL+B]) (A) ; Compares data
B++
else
break
endif
next

```

```

DSPLEV=B (A) ; Determines display data

if_bit(!T1SF) ; 1 s (hold level updated)
    X=HLDLEV (A) ; Compares hold and display levels
    if(X<DSPLEV) (A)
        HLDLEV=DSPLEV (A)
    endif
else
    CLR1 T1SF
    HLDLEV=DSPLEV (A)
endif

HL=#DSPTBL
A=DSPLEV ; Creates display level
A+=A
B=A
A=HLDLEV
A+=A
C=A
X=[HL+B] (A)
B++
A=[HL+B]
HL=#HLDTBL ; Creates hold level
A<->X
A|=[HL+C]
A<->X
C++
A|=[HL+C]
BC=AX

HL=#DSPDAT ; Sets segment signal of first digit
A=C
A&=#0FH
A|#00010000B ; Sets digit signal
[HL]=A
HL++
A=C ; Sets segment signal of second digit
A>>=1
A>>=1
A>>=1
A>>=1
A&=#0FH
A|#00100000B ; Sets digit signal
[HL]=A
HL++
A=B ; Sets segment signal of third digit
A&=#0FH
A|#01000000B ; Sets digit signal
[HL]=A
HL++
A=B ; Sets segment signal of fourth digit
A>>=1
A>>=1
A>>=1
A>>=1
A&=#0FH ; Sets digit signal
A|#10000000B
[HL]=A
endif

```

```
RET
LEVTBL:
DB      0AH
DB      12H
DB      20H
DB      2EH
DB      39H
DB      40H
DB      48H
DB      51H
DB      5BH
DB      66H
DB      72H
DB      80H
DB      90H
DB      0A2H
DB      0B5H
DB      0FFH

DSPTBL:
DW      0000000000000000B
DW      0000000000000001B
DW      0000000000000011B
DW      0000000000000111B
DW      0000000000001111B
DW      0000000000011111B
DW      0000000001111111B
DW      0000000111111111B
DW      0000001111111111B
DW      0000011111111111B
DW      0000111111111111B
DW      0001111111111111B
DW      0011111111111111B
DW      0111111111111111B
DW      1111111111111111B

HLDTBL:
DW      0000000000000000B
DW      0000000000000001B
DW      0000000000000010B
DW      0000000000000100B
DW      0000000000001000B
DW      0000000000010000B
DW      0000000001000000B
DW      0000000010000000B
DW      0000000100000000B
DW      0000010000000000B
DW      0000100000000000B
DW      0001000000000000B
DW      0010000000000000B
DW      0100000000000000B
DW      1000000000000000B

$EJECT
```

```
;*****  
*           Level meter data  
;*****  
TM1_SEG CSEG  
INTTM1:  
    SEL RB0 ; Turns OFF digit and segment signals  
    P6=#0000000B  
    HL=#DSPDAT  
    B=DIGCNT (A)  
    P6=[HL+B] (A)  
    DIGCNT++  
    DIGCNT&=#00000011B ; 20 ms?  
    CT20MS--  
    if(CT20MS==#0) ; Sets initial counter value  
        CT20MS=#10  
        SET1 T20MSF ; 1s?  
        CT1S--  
        if(CT1S==#0) ; Sets initial counter value  
            CT1S=#50  
            SET1 T1SF  
        endif  
    endif  
    RETI
```

## 9.2 Thermometer

In this application example, a temperature in a range of  $-20^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$  is measured by using a thermistor ( $6\text{ k}\Omega/0^{\circ}\text{C}$ ) as a temperature sensor. Changes in the resistance of the thermistor with respect to temperature are given by the following expression:

$$R = R_0 \exp \{ B (1/T - 1/T_0) \}$$

where,

R : resistance at given temperature T [ $^{\circ}\text{K}$ ]

T : given temperature [ $^{\circ}\text{K}$ ]

$R_0$  : resistance at reference temperature  $T_0$  [ $^{\circ}\text{K}$ ]

$T_0$  : reference temperature [ $^{\circ}\text{K}$ ]

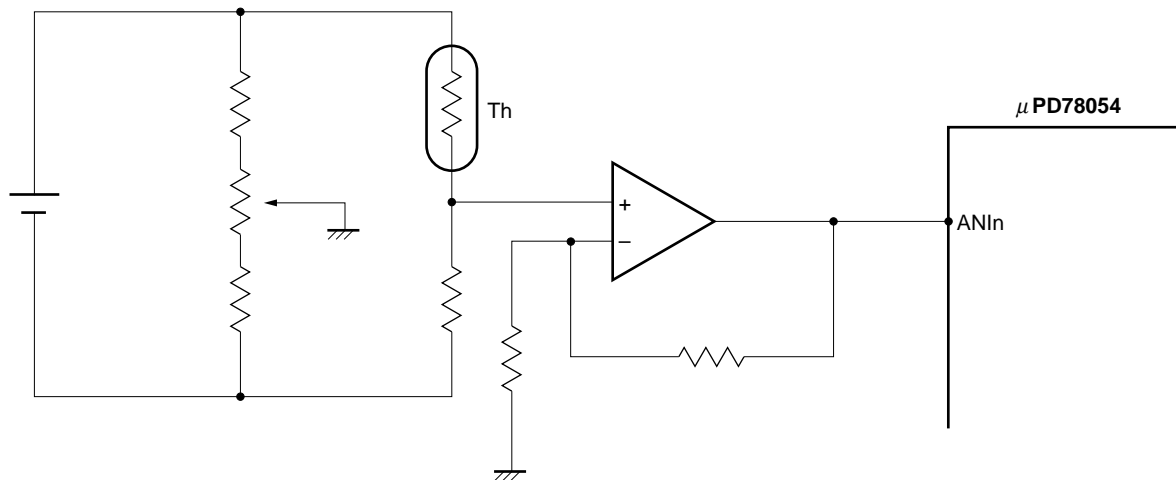
B : constant obtained by reference temperature  $T_0$  [ $^{\circ}\text{K}$ ] and  $T_0$  [ $^{\circ}\text{K}$ ]

Constant B changes with the temperature. This constant can be calculated by changing the above expression as follows:

$$B = \frac{1}{(1/T - 1/T_0)} \ln \frac{R}{R_0}$$

Figure 9-12 shows a circuit example. This circuit is designed to input 0 V at  $-20^{\circ}\text{C}$ , and 5 V at  $+50^{\circ}\text{C}$ .

Figure 9-12. Circuit Example of Thermometer



Because the characteristic of the thermistor is non linear in this example, the input analog voltage is not converted to a temperature in a range of  $-20\text{ }^{\circ}\text{C}$  to  $+50\text{ }^{\circ}\text{C}$  through calculation but by comparison with table data. This conversion result is stored to RAM (DSPDAT) as 2-digit BCD. Figure 9-13 shows the characteristics of the thermistor, and Table 9-1 shows the relations between temperature and A/D conversion value.

To measure the temperature, four conversion values are averaged and converted to a temperature. The result of the conversion is stored in a display area. Therefore, the data is updated once every four times. For example, if measurement processing is executed every 250 ms, the display updating cycle is 1 second.

**Figure 9-13. Temperature vs. Output Characteristic**

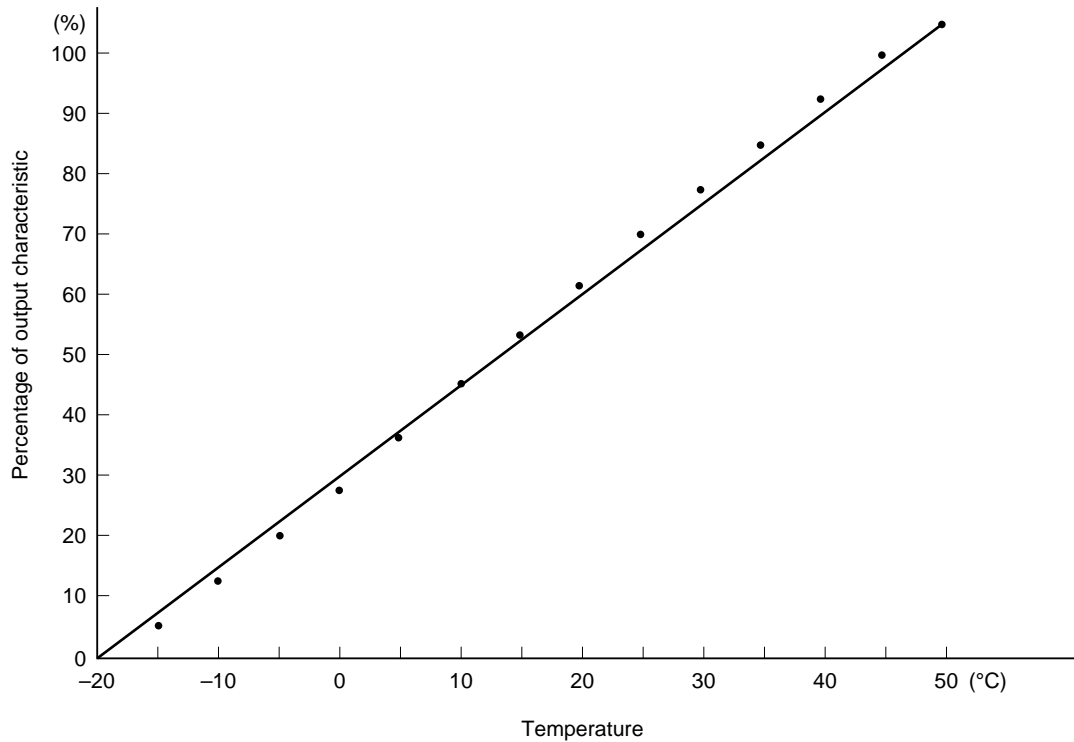


Table 9-1. A/D Conversion Value and Temperature

| Conversion Value | Temperature [°C] | Conversion Value | Temperature [°C] | Conversion Value | Temperature [°C] | Conversion Value | Temperature [°C] |
|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 00               | -20.0            | 38               | -2.5             | 82               | 15.5             | CB               | 33.5             |
| 01               | -19.5            | 3C               | -1.5             | 86               | 16.5             | CE               | 34.5             |
| 04               | -18.5            | 40               | -0.5             | 8B               | 17.5             | D2               | 35.5             |
| 07               | -17.5            | 44               | 0.5              | 8F               | 18.5             | D6               | 36.5             |
| 0A               | -16.5            | 48               | 1.5              | 93               | 19.5             | D9               | 37.5             |
| 0C               | -15.5            | 4C               | 2.5              | 97               | 20.5             | DC               | 38.5             |
| 0F               | -14.5            | 50               | 3.5              | 9B               | 21.5             | E0               | 39.5             |
| 12               | -13.5            | 54               | 4.5              | 9F               | 22.5             | E3               | 40.5             |
| 16               | -12.5            | 58               | 5.5              | A3               | 23.5             | E7               | 41.5             |
| 19               | -11.5            | 5C               | 6.5              | A8               | 24.5             | EA               | 42.5             |
| 1C               | -10.5            | 60               | 7.5              | AC               | 25.5             | ED               | 43.5             |
| 1F               | -9.5             | 64               | 8.5              | B0               | 26.5             | F0               | 44.5             |
| 23               | -8.5             | 69               | 9.5              | B4               | 27.5             | F3               | 45.5             |
| 26               | -7.5             | 6D               | 10.5             | B7               | 28.5             | F6               | 46.5             |
| 2A               | -6.5             | 71               | 11.5             | BB               | 29.5             | F9               | 47.5             |
| 2D               | -5.5             | 75               | 12.5             | BF               | 30.5             | FC               | 48.5             |
| 31               | -4.5             | 7A               | 13.5             | C3               | 31.5             | FE               | 49.5             |
| 35               | -3.5             | 7E               | 14.5             | C7               | 32.5             | FF               | 50.0             |

**(1) Description of package****<Public declaration symbol>**

THMETER : Thermometer subroutine call name  
 DSPDAT : Display data storage area  
 CNTPRO : Test counter counting number of inputs  
 MINUSF : Minus temperature display flag  
 T250MSF : 250-ms setting flag

**<Register used>**

AX, BC, HL



**<RAM used>**

| Name   | Usage                             | Attribute | Bytes |
|--------|-----------------------------------|-----------|-------|
| ADDAT  | Stores A/D conversion value       | SADDR     | 4     |
| DSPDAT | Stores display data               |           | 2     |
| CNTPRO | Test counter for number of inputs |           | 1     |
| WORKCT | Work counter for loop processing  |           |       |

**<Flag used>**

| Name    | Usage                                    |
|---------|--|
| T250MSF | Executes measurement processing when set |
| MINUSF  | Set when temperature is below zero       |

**<Nesting>**

1 level 2 bytes

**<Hardware used>**

A/D converter

**<Initial setting>**

ADM = #1000xxx1B; Selects A/D converter channel and starts operation

**<Starting>**

Set the T250MSF flag in each measurement cycle by using timer processing. After that, call THMETER at least once in measurement cycle.

(2) Example of use

```

        EXTRN    THMETER,DSPDAT,CNTPRO
        EXTBIT   MINUSF,T250MSF

AD_DAT  DSEG    SADDR
CT250MS:DS    1                ; 250 ms counter
LEDD:    DS     4                ; LED display area
DIGCT:   DS     1                ; LED display digit counter

VETM3   CSEG    AT 1EH
        DW      INTTM3          ; Sets vector address of watch timer

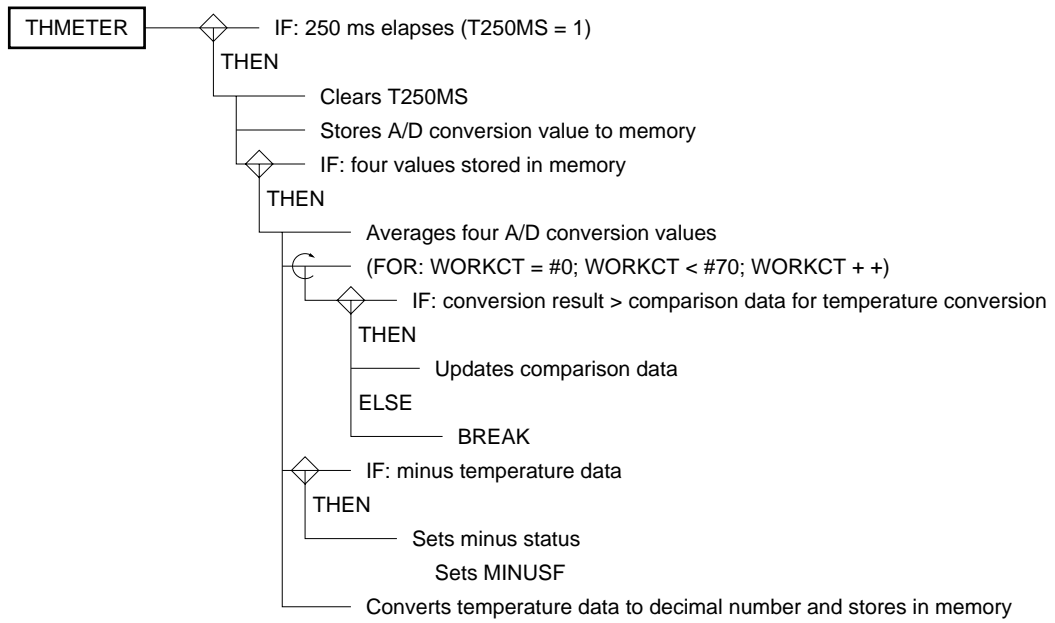
        MOV     TMC2,#00100110B ; Sets watch timer to 1.95 ms
        CLR1   TMMK3

        .
        .
        CT250MS=#128
        CNTPRO=#4
        ADM=#10000011B        ; Selects ANI1 pin and starts operation
        .
        .

;*****
;      Watch timer interrupt processing
;      Interval time: 1.95 ms
;*****
INTTM3:                                ; 1.95 ms interrupt processing
        .
        .
        DBNZ   CT250MS,$RTNTM3
        MOV    CT250MS,#128        ; 250 ms elapses
        SET1   T250MSF

RTNTM3:
        .
        .
        RETI
    
```

(3) SPD chart



## (4) Program list

```

PUBLIC THMETER, DSPDAT, CNTPR0, T250MSF, MINUSF

AD_DAT DSEG SADDR
ADDAT: DS 4 ; A/D conversion result storage area
DSPDAT: DS 2 ; Display data
CNTPR0: DS 1 ; Tests number of inputs
WORKCT: DS 1

AD_FLG BSEG
T250MSF DBIT ; Sets 250 ms
MINUSF DBIT ; Sets minus data

TH_SEG CSEG
;*****
* Sets temperature data
;*****
THMETER:
    if_bit(T250MSF) ; 250 ms
        CLR1 T250MSF
        A=ADCR
        A<->ADDAT
        A<->ADDAT+1
        A<->ADDAT+2
        A<->ADDAT+3

        CNTPR0--
        if(CNTPR0==#0)
            CNTPR0=#4
            AX=#0H
            HL=#ADDAT ; Data storage address
            for(WORKCT=#0;WORKCT<#4;WORKCT++)
                A+=[HL]
                HL++
                if_bit(CY) ; Carry occurs
                X++ ; Carry
            endif
        next

        A<->X
        C=#4
        AX/=C ; AX/C = AX (quotient) ... C (remainder)
        if(C>=#2) (A) ; Remainder processing (2 digits or more carried)
            X++ ; Carry processing
        endif

        A=X ; Converts to temperature data
        B=#0
        HL=#THRTBL
        if(A==#0FFH)
            B=#70
        else
            for(WORKCT=#0;WORKCT<#70;WORKCT++)
                if(X>=[HL+B]) (A)
                    B++
                else
                    break
                endif
            next

```

```
endif

CLR1    MINUSF
A=#20                                     ; Temperature data 20
B=-A
if_bit(CY)                               ; To decimal conversion
    SET1    MINUSF
    A=#0
    A=-B                                   ; Absolute value of data
    A<->B
endif
X=#0                                     ; Decimal conversion
A=B
A<->X
C=#10
AX/=C                                     ; Temperature data/10
DSPDAT=C (A)                             ; Updates display data
(DSPDAT+1)=X (A)
endif
endif
RET
```

```
THRTBL;
;
DB      1          ; -19.5
DB      4          ; -18.5
DB      7          ; -17.5
DB      0AH        ; -16.5
DB      0CH        ; -15.5
DB      0FH        ; -14.5
DB      12H        ; -13.5
DB      16H        ; -12.5
DB      19H        ; -11.5
DB      1CH        ; -10.5
DB      1FH        ; -9.5
DB      23H        ; -8.5
DB      26H        ; -7.5
DB      2AH        ; -6.5
DB      2DH        ; -5.5
DB      31H        ; -4.5
DB      35H        ; -3.5
DB      38H        ; -2.5
DB      3CH        ; -1.5
DB      40H        ; -0.5
DB      44H        ; +0.5
DB      48H        ; 1.5
DB      4CH        ; 2.5
DB      50H        ; 3.5
DB      54H        ; 4.5
DB      58H        ; 5.5
DB      5CH        ; 6.5
DB      60H        ; 7.5
DB      64H        ; 8.5
DB      69H        ; 9.5
DB      6DH        ; 10.5
DB      71H        ; 11.5
DB      75H        ; 12.5
DB      7AH        ; 13.5
DB      7EH        ; 14.5
DB      82H        ; 15.5
DB      86H        ; 16.5
DB      8BH        ; 17.5
DB      8FH        ; 18.5
DB      93H        ; 19.5
DB      97H        ; 20.5
DB      9BH        ; 21.5
DB      9FH        ; 22.5
DB      0A3H       ; 23.5
DB      0A8H       ; 24.5
DB      0ACH       ; 25.5
DB      0B0H       ; 26.5
DB      0B4H       ; 27.5
DB      0B7H       ; 28.5
DB      0BBH       ; 29.5
DB      0BFH       ; 30.5
DB      0C3H       ; 31.5
DB      0C7H       ; 32.5
DB      0CBH       ; 33.5
DB      0CEH       ; 34.5
DB      0D2H       ; 35.5
DB      0D6H       ; 36.5
```

|    |      |        |
|----|------|--------|
| DB | 0D9H | ; 37.5 |
| DB | 0DCH | ; 38.5 |
| DB | 0E0H | ; 39.5 |
| DB | 0E3H | ; 40.5 |
| DB | 0E7H | ; 41.5 |
| DB | 0EAH | ; 42.5 |
| DB | 0EDH | ; 43.5 |
| DB | 0F0H | ; 44.5 |
| DB | 0F3H | ; 45.5 |
| DB | 0F6H | ; 46.5 |
| DB | 0F9H | ; 47.5 |
| DB | 0FCH | ; 48.5 |
| DB | 0FFH | ; 49.5 |

### 9.3 Analog Key Input

In this example, sixteen keys are input by using the A/D converter. To input keys, a circuit must be designed so that a voltage peculiar to a key is input to the A/D converter when the key is pressed.

Because sixteen keys are input in this example,  $V_{DD}$  is divided by 16 and the voltage of each key is converted into a key code. Table 9-2 shows the relations between the input voltages and key codes (00H through 0FH). When no key input is made, the key code is 10H.

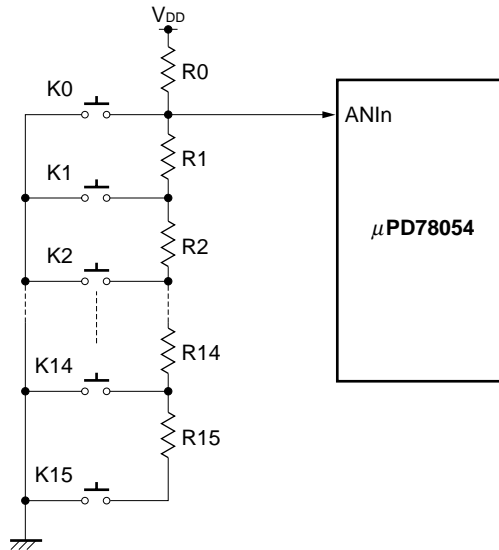
**Table 9-2. Input Voltage and Key Code**

| Input Voltage V | A/D Conversion Value | Key Code |
|-----------------|----------------------|----------|
| GND             | 00-07H               | 00H      |
| 1/16 $V_{DD}$   | 08-17H               | 01H      |
| 2/16 $V_{DD}$   | 18-27H               | 02H      |
| 3/16 $V_{DD}$   | 28-37H               | 03H      |
| 4/16 $V_{DD}$   | 38-47H               | 04H      |
| 5/16 $V_{DD}$   | 48-57H               | 05H      |
| 6/16 $V_{DD}$   | 58-67H               | 06H      |
| 7/16 $V_{DD}$   | 68-77H               | 07H      |
| 8/16 $V_{DD}$   | 78-87H               | 08H      |
| 9/16 $V_{DD}$   | 88-97H               | 09H      |
| 10/16 $V_{DD}$  | 98-A7H               | 0AH      |
| 11/16 $V_{DD}$  | A8-B7H               | 0BH      |
| 12/16 $V_{DD}$  | B8-C7H               | 0CH      |
| 13/16 $V_{DD}$  | C8-D7H               | 0DH      |
| 14/16 $V_{DD}$  | D8-E7H               | 0EH      |
| 15/16 $V_{DD}$  | E8-F7H               | 0FH      |
| $V_{DD}$        | F8-FFH               | 10H      |

Figure 9-14 shows an example of the circuit that satisfies the above relations between the input voltages and key codes. Note, however, that this circuit gives a priority to the key with the lower number if two or more keys are pressed at the same time.



Figure 9-14. Example of Analog Key Input Circuit



Resistances R0 through R15 used in the circuit in Figure 9-14 can be calculated by the following expression:

$$\sum_{K=1}^n R_K = \frac{n \times R_0}{16-n}$$

Table 9-3 shows the resistances of R1 through R15 where R0 is 1 kΩ in the above expression (the calculation result of a resistance may slightly differ from the resistance of commercial resistors indicated by a color code).

Table 9-3. Resistances of R1 through R5

| Resistor No. | Resistance Value Ω | Resistor No. | Resistance Value Ω | Resistor No. | Resistance Value Ω |
|--------------|--------------------|--------------|--------------------|--------------|--------------------|
| R1           | 68                 | R6           | 150                | R11          | 560                |
| R2           | 75                 | R7           | 180                | R12          | 750                |
| R3           | 82                 | R8           | 220                | R13          | 1.3 k              |
| R4           | 100                | R9           | 270                | R14          | 2.7 k              |
| R5           | 120                | R10          | 390                | R15          | 8.2 k              |

This program converts an input analog voltage into the corresponding key code shown in Table 9-2, absorbs chattering, and then stores the input voltage to RAM. To absorb chattering, a key code is assumed to be valid when it coincides with a given value five times in succession. For example, if an analog voltage is sampled every 5 ms, chattering of 20 to 25 ms is absorbed. If a key input is changed, a key change flag (KEYCHG) is set.

**(1) Description of package**

**<Public declaration symbol>**

AKEYIN : Analog key input subroutine name  
 KEYDAT : Key code storage area  
 PASTDT : Key code storage area for chattering absorption  
 CHATCT : Chattering absorption counter  
 KEYCHG : Key change test flag  
 CHTENDF : Flag to test end of chattering absorption  
 KEYOFF : Key code when there is no key input

**<Register used>**

A

**<RAM used>**

| Name    | Usage                                     | Attribute | Bytes |
|---------|---|-----------|-------|
| PASTDAT | Stores key code for chattering absorption | SADDR     | 1     |
| KEYDAT  | Stores key code                           |           |       |
| CHATCNT | Chattering counter                        |           |       |

**<Flag used>**

| Name    | Usage                                |
|---------|--------------------------------------|
| KEYCHG  | Set when key is changed              |
| CHTENDF | Sets when chattering absorption ends |

**<Nesting>**

1 level 2 bytes

**<Hardware used>**

A/D converter

**<Initial setting>**

ADM = #1000xxx1B; Selects A/D converter channel and starts operation

**<Starting>**

- Call AKEYIN at fixed interval.
- Input a key code after testing the key change flag. Note that this flag is not cleared by the subroutine and must be cleared after the flag has been tested.

## (2) Example of use

```

        EXTRN    AKEYIN,KEYDAT,PASTDT,CHATCT
        EXTRN    KEYOFF

        EXTBIT   KEYCHG,CHTENDF

VETM3   CSEG    AT 1EH
        DW      INTTM3                ; Sets vector address of watch timer

MAINDAT DSEG    SADDR
CT5MS:  DS      1

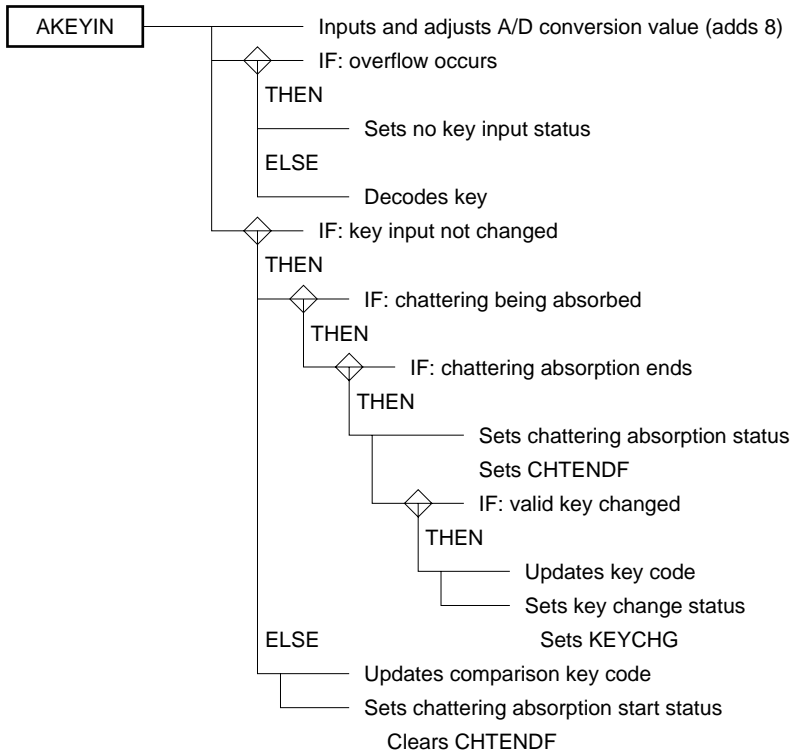
        TMC2=#00100110B
        CLR1    TMMK3
        CT5MS=#3

        KEYDAT=#KEYOFF                ; Sets OFF data as key data
        PASTDT=#KEYOFF
        CHATCT=#CHVAL                  ; Sets number of times of chattering to five
        CLR1    CHTENDF
        CLR1    KEYCHG
        ADM=#10000101B                ; Selects ANI2 pin and starts operation
        EI
        :
        :
        if_bit(KEYCHG)                  ; Key changed?
                CLR1    KEYCHG
                ; Key input processing
        endif
        :
        :
;*****
;      Watch timer interrupt processing
;      Interval: 1.95 ms
;*****
INTTM3:                ; 1.95 ms interrupt processing
        :
        :
        DBNZ    CT5MS,$RTNTM3
        MOV     CT5MS,#3                ; 1.95 ms × 3 elapses
        CALL    !AKEYIN

RTNTM3:
        :
        :
        RETI

```

(3) SPD chart



(4) Program list

```

PUBLIC AKEYIN,KEYDAT,PASTDT
PUBLIC CHATCT,KEYOFF
PUBLIC KEYCHG,CHTENDF
AK_DAT DSEG SADDR ; Key data storage area
KEYDAT: DS 1 ; Chattering key data
PASTDT: DS 1 ; Chattering counter
CHATCT: DS 1

AK_FLG BSEG ; Key changed
KEYCHG DBIT ; Chattering absorption end status
CHTENDF DBIT ; OFF key data

KEYOFF EQU 10H ; Number of times of chattering absorption
CHAVAL EQU 5

AK_SEG CSEG
;*****
* Analog key input
;*****
AKEYIN: ; Inputs A/D conversion value
A=ADCR ; Corrects data
A+=#8
if_bit(CY) ; Sets no key input status
A=#KEYOFF ; Decodes key
else
A>>=1
A>>=1
A>>=1
A>>=1
A&=0FH
endif ; No key change
if(A==PASTDT) ; Chattering being absorbed
if_bit(!CHTENDF) ; End of chattering absorption
CHATCT--
if(CHATCT==#0) ; Sets chattering absorption status
SET1 CHTENDF
A=PASTDT ; Valid key changed
if(A!=KEYDAT) ; Updates key data
KEYDAT=A ; Sets key change status
SET1 KEYCHG
endif
endif
endif ; Updates previous key data
PASTDT=A ; Starts chattering absorption
CHATCT=#CHAVAL-1
CLR1 CHTENDF
endif
RET

```

## 9.4 4-Channel Input A/D Conversion

This section describes the method to scan four channels for A/D conversion. The A/D conversion operation is started by the software.

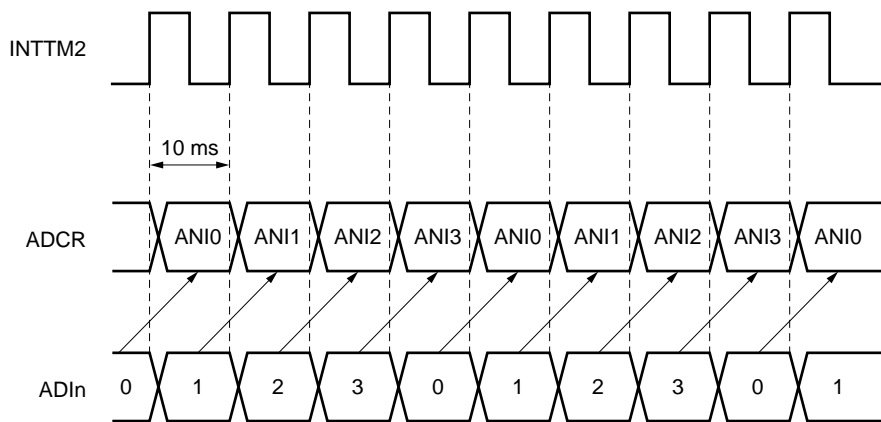
The analog voltages input to the selected four channels are converted into digital signals. The result of the A/D conversion of each channel is stored in RAM.

An interrupt request is generated by using 8-bit timer/event counter 1. The result of the conversion is loaded and channel is converted in the processing of this interrupt request. Because 8-bit timer/event counter 1 is set to 10 ms, it is not necessary to measure the wait time of the A/D conversion.

**Caution** To change the interrupt time, make the following setting:

- Set timer longer than  $\left\{ \begin{array}{l} \text{A/D conversion end time} + \text{Interrupt entry} \\ \text{return time} + \text{Interrupt processing time.} \end{array} \right\}$
- Test flags that indicate the end of the conversion.

Figure 9-15. Timing Chart in 4-Channel Scan Mode



**(1) Description of package****<Public declaration symbol>**

- Output parameter
  - M\_CH0 : Stores conversion result of channel 0
  - M\_CH1 : Stores conversion result of channel 1
  - M\_CH2 : Stores conversion result of channel 2
  - M\_CH3 : Stores conversion result of channel 3

**<Register used>**

A

**<RAM used>**

| Name   | Usage                                    | Attribute | Bytes |
|--------|--|-----------|-------|
| M_CH0  | Channel 0 conversion result storage area | SADDR     | 1     |
| M_CH1  | Channel 1 conversion result storage area | SADDR     | 1     |
| M_CH2  | Channel 2 conversion result storage area | SADDR     | 1     |
| M_CH3  | Channel 3 conversion result storage area | SADDR     | 1     |
| M_MODE | Mode storage area                        | SADDR     | 1     |

**<Nesting>**

1 level 3 bytes

**<Hardware used>**

- A/D converter
- 8-bit timer/event counter 1
- Port 1 (P10-P13)

**<Initial setting>**

- OSMS = #00000001B ; Oscillation mode select register: does not use divider circuit
- ADM = #1000xxxxB ; Selects A/D converter channel and starts operation
- ADIS = #00000100B ; Selects number of A/D converter channels
- TCL1 = #00001110B ; Interval time of 8-bit timer/event counter 1: 10 ms
- TMC1 = #00000001B
- CR10 = #81
- Enables TMMK1 interrupt

(2) Example of use

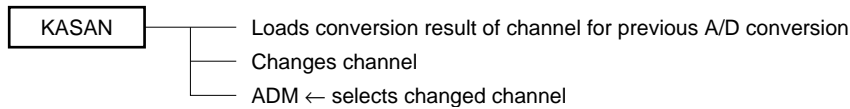
```

EXTRN  M_CH0,M_CH1,M_CH2,M_CH3,M_MODE
;*****
;          Initialize
;*****
M4      CSEG          ;
RES_STA:
    SEL RB0          ;
    DI               ;
        :
        :
    OSMS=#0000001B   ; Does not use divider circuit
    ADM=#1000001B    ; Starts A/D operation and selects external trigger channel 0
    ADIS=#00000100B  ; Selects analog input channel 4
    CR10=#81         ; Sets modulo register 81
    TCL1=#00001110B  ; Count clock: 8.2 kHz
    TMC1=#00000001B  ; Enables 8-bit timer/register 1 operation
    CLR1  TMIF1      ; Clears timer 1 interrupt request flag
    CLR1  TMMK1      ; Enables timer 1 interrupt
    EI               ;
    M_MODE=#0        ; Sets initial value (0 channel) to mode area
        :
    while(forever)   ;
        :
        A=M_CH0      ; A ← data of channel 0
        :
        A=M_CH1      ; A ← data of channel 1
        :
        A=M_CH2      ; A ← data of channel 2
        :
        A=M_CH3      ; A ← data of channel 3
        :

```

(3) SPD chart

[A/D conversion processing]





## (4) Program list

```

;*****
;           A/D conversion
;*****
;
$PC(054)           ;
;
PUBLIC  M_CH0,M_CH1,M_CH2,M_CH3,M_MODE      ;
;
VEINTM1 CSEG      AT 24H
          DW  KASAN
;*****
;           RAM definition
;*****
          DSEG      SADDR
M_CH0:    DS        1           ; Area for channel 0 addition
M_CH1:    DS        1           ; Area for channel 1 addition
M_CH2:    DS        1           ; Area for channel 2 addition
M_CH3:    DS        1           ; Area for channel 3 addition
M_MODE:   DS        1           ; Mode storage area
;
          CSEG           ;
KASAN:
          SEL  RB2           ; Selects bank 2
          switch(M_MODE)    ; Channel currently selected?
          case 0:           ; Channel 0:
              M_CH0=ADCR (A) ; Transfers conversion result to RAM
              M_MODE++      ;
              ADM=#1000011B ; Select channel 1:
              break         ;
          case 1:           ; Channel 1:
              M_CH1=ADCR (A) ; Transfers conversion result to RAM
              M_MODE++      ;
              ADM=#10000101B ; Selects channel 2
              break         ;
          case 2:           ; Channel 2:
              M_CH2=ADCR (A) ; Transfers conversion result to RAM
              M_MODE++      ;
              ADM=#10000111B ; Selects channel 3
              break         ;
          case 3:           ; Channel 3:
              M_CH3=ADCR (A) ; Transfers conversion result to RAM
              M_MODE=#0      ;
              ADM=#10000001B ; Selects channel 0
              break         ;
          ends
          RETI
          END

```

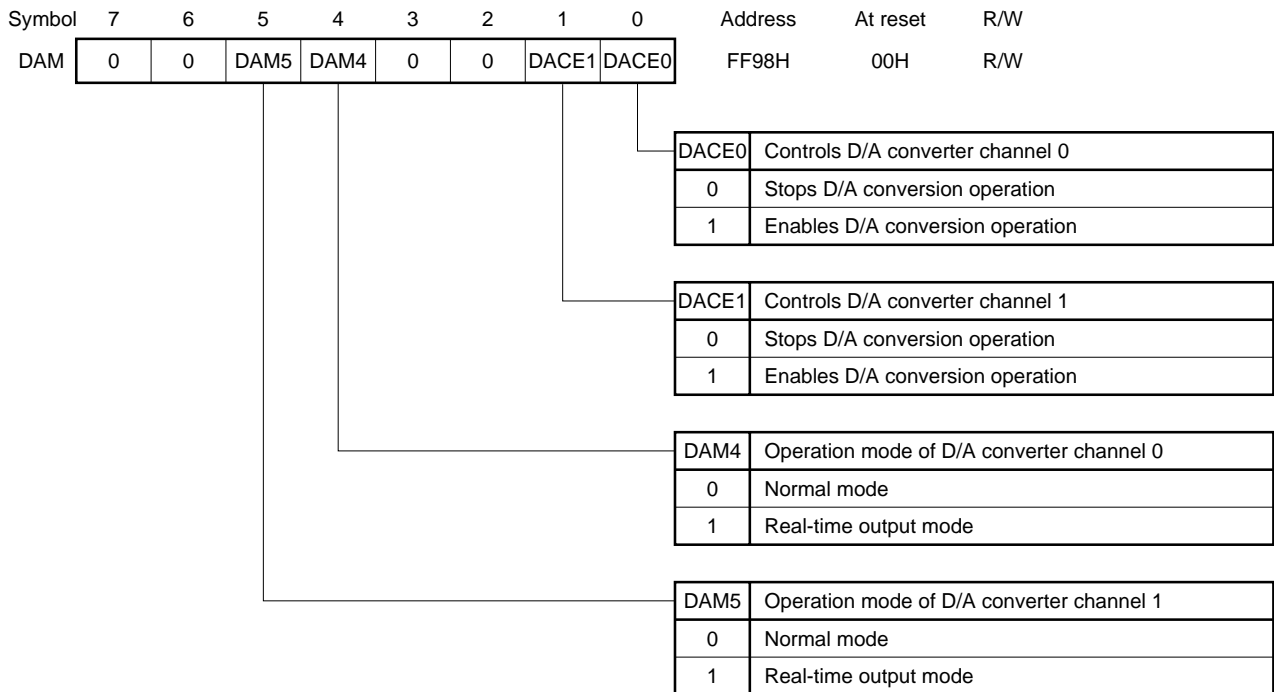
[MEMO]

## CHAPTER 10 APPLICATIONS OF D/A CONVERTER

The D/A converter of the 78K/0 series consists of two voltage output type D/A converter channels with an 8-bit resolution. This D/A can be used in two modes: normal mode and real-time output mode. In the normal mode, the output trigger is writing data to the D/A conversion value setting registers 0 and 1 (DACS0 and 1). In the real-time output mode, the output is triggered by the interrupt requests (INTTM1 and 2) of 8-bit timer/event counters 1 and 2. In this mode, set data to DACS0 and DACS1 after an output trigger has been generated until the next output trigger is generated.

The D/A converter is set by the D/A converter mode register.

**Figure 10-1. Format of D/A Converter Mode Register**



- Cautions**
1. To use the D/A converter, set the multiplexed port pins in the input mode and disconnect the pull-up resistor.
  2. Be sure to clear bits 2, 3, 6, and 7 to 0.
  3. The output goes into a high-impedance state when D/A conversion operation is stopped.
  4. The output trigger in the real-time output mode is INTTM1 for channel 0 and INTTM2 for channel 1.

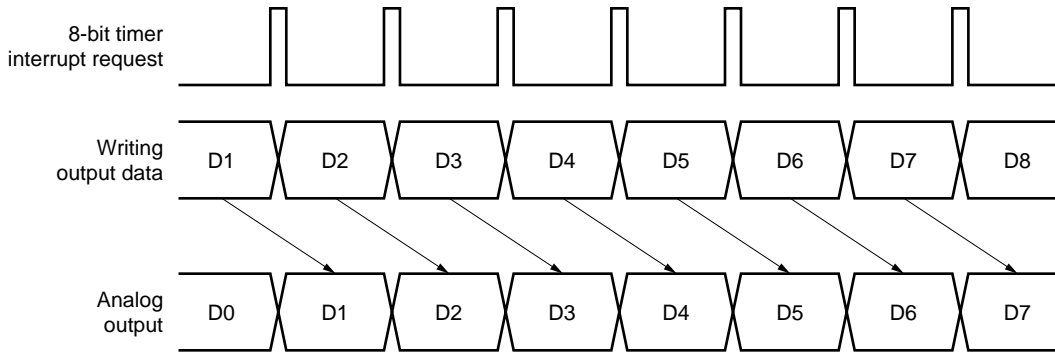
### 10.1 SIN Wave Output

This section introduces an example that outputs a SIN wave with a frequency of 50 Hz by using the real-time output mode of D/A converter channel 0.

After the output operation has been started, an analog value resulting from the D/A conversion specified by the D/A conversion value setting register 0 (DACS0) is output, and the next output data is set to DACS0 by interrupt processing. The value set by the interrupt processing is output at the next timing of 8-bit timer/event counter 1.

Figure 10-2 shows the output data writing timing and analog output timing.

**Figure 10-2. Analog Output and Output Data Storage Timing**

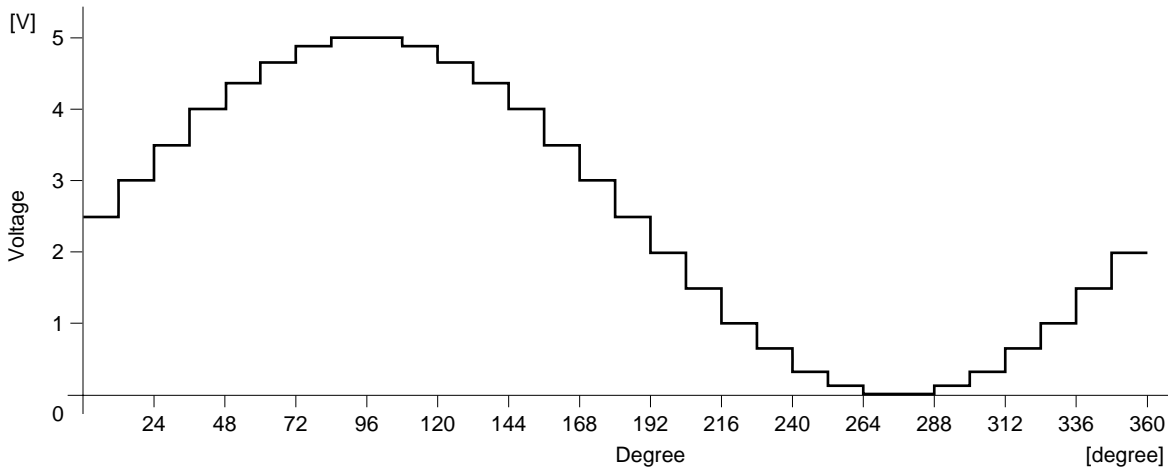


The interval time of 8-bit timer/event counter 1 is set to about 668  $\mu$ s and a 50-Hz D/A output wave is generated as shown in Figure 10-3.

The SIN wave output data is stored in ROM. Data are sequentially referenced by the interrupt processing of 8-bit timer/event counter 1 and written to DACS0.

Table 10-1 shows the voltages for SIN wave output and set values.

**Figure 10-3. D/A Output Waveform**



**Table 10-1. Voltage of SIN Wave Output and Preset Value**

| Degree | Voltage (V) | Set Value | Degree | Voltage (V) | Set Value |
|--------|-------------|-----------|--------|-------------|-----------|
| 0      | 2.5000      | 80H       | 180    | 2.5000      | 80H       |
| 12     | 3.0200      | 9BH       | 192    | 1.9802      | 65H       |
| 24     | 3.5168      | B4H       | 204    | 1.4832      | 4CH       |
| 36     | 3.9695      | CBH       | 216    | 1.0305      | 35H       |
| 48     | 4.3579      | DFH       | 228    | 0.6421      | 21H       |
| 60     | 4.6651      | EFH       | 240    | 0.3349      | 11H       |
| 72     | 4.8776      | FAH       | 252    | 0.1224      | 06H       |
| 84     | 4.9863      | FFH       | 264    | 0.0137      | 01H       |
| 96     | 4.9863      | FFH       | 276    | 0.0137      | 01H       |
| 108    | 4.8776      | FAH       | 288    | 0.1224      | 06H       |
| 120    | 4.6651      | EFH       | 300    | 0.3349      | 11H       |
| 132    | 4.3579      | DFH       | 312    | 0.6421      | 21H       |
| 144    | 3.9695      | CBH       | 324    | 1.0305      | 35H       |
| 156    | 3.5168      | B4H       | 336    | 1.4832      | 4CH       |
| 168    | 3.0200      | 9BH       | 348    | 1.9802      | 65H       |

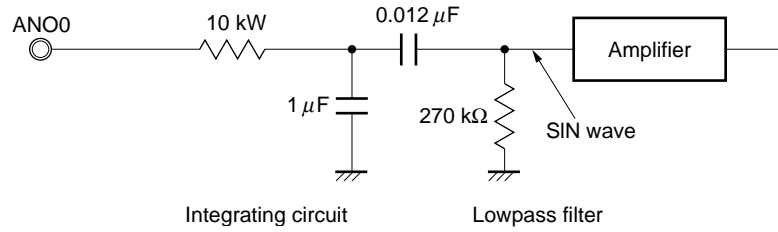
**Remark** The analog voltage output to the ANO0 pin is determined by the following expression:

$$\text{ANO0 pin output voltage} = \frac{AV_{REF1} \times \text{DACS0}}{256}$$

**Caution** The voltage values shown in Table 10-1 is rounded off at the fifth position after the decimal point. However, the preset value is calculated with the data before rounding off. The resultant data is rounded off at the first position after the decimal point.

The output analog value is processed by the SIN wave conversion circuit shown in Figure 10-4 to create a SIN wave without step.

Figure 10-4. SIN Wave Conversion Circuit



(1) Description of package

<Public declaration symbol>

- Data definition reference name
  - SDATA : First address of SIN wave output data to be stored to DACS0 register
  - ENDDAT : Last pointer of SIN wave data
- Input/output parameter
  - C\_DATA : ROM data counter

<Register used>

Bank 3; AX, HL, B

<RAM used>

| Name   | Usage   | Attribute | Bytes |
|--------|---|-----------|-------|
| C_DATA | Counter indicating pointer that extracts SIN wave output data | SADDR     | 1     |

<Flag used>

None

<Nesting level>

1 level 3 bytes

**<Hardware used>**

- D/A converter
- 8-bit timer/event counter 1

**<Initial setting>**

- OSMS = #00000001B ; Oscillation mode select register: does not use divider circuit
- PM13 = #xxxxxxxx1B ; Sets port 13 in input mode
- TCL1 = #xxx1001B ; Interval of 8-bit timer/event counter: 668  $\mu$ s  
TMC1 = #000000x0B  
CR10 = #174
- DACS0 = #80H ; Sets D/A converter  
DAM = #00000001B
- SET1 DAM.4 ; Sets D/A converter in real-time output mode
- SET1 TCE1 ; Enables operation of 8-bit timer/event counter 1 and enables interrupt  
CLR1 TMIF1  
CLR1 TMMK1

**Caution** To prevent output of a value on resetting and starting, once set the normal mode and write the initial value to the D/A conversion value setting register 0 (DACS0), and then output the initial value. After that, set the real-time output mode, and enable the operation of 8-bit timer/event counter 1 and interrupt.

If D/A conversion is started in the real-time output mode after reset and start with the initial value set to the DACS0 register, 0 V (data D0 in Figure 10-2. Analog Output and Output Data Storage Timing) is output.

**<Starting>**

When starting output, enable the operation of the D/A converter (by setting bit 4 (DAM4) of the D/A converter mode register(DAM)), the operation of 8-bit timer/event counter 1 (by setting bit 0 (TCE) of the 8-bit timer mode control register (TMC1)), and interrupts (by clearing TMIF1 and TMMK1).

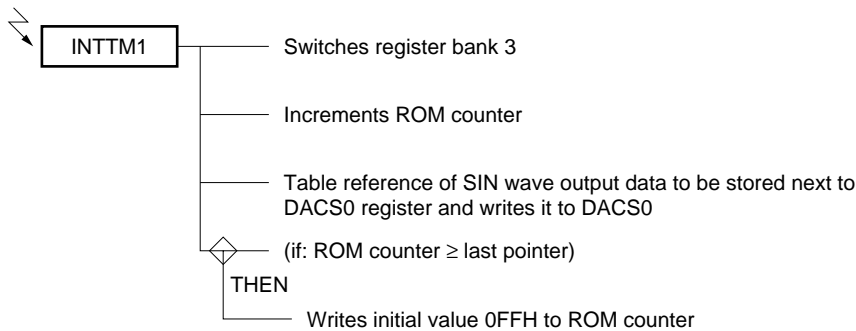
(2) Example of use

```

EXTRN  C_DATA, SDATA, ENDDAT
;
F_RIARU  EQU      DAM.4      ; Real-time output port setting flag
;
      :
OSMS=#00000001B      ; Does not use divider circuit
TCL1=#00001001B      ; SIN_DAT; 8-bit timer 1. Count clock: 262 kHz
CR10=#175-1          ; 8-bit timer 1. Interval: 668 μs
TMC1=#00000000B      ; Disables 8-bit timer 1 operation
;
HL=#SDATA             ;
B=C_DATA (A)          ;
DACS0=[HL+B] (A)     ;
DAM=#00000001B       ; Enables D/A conversion operation of channel 0 in normal mode
PM13=#11111111B     ; Sets P130 in input port mode
EI
      :
      :
if_bit(SIN wave output data start);
  SET1  F_RIARU      ; Sets channel 0 in real-time output mode
  C_DATA=#0          ; Sets initial value to conversion value setting register
  HL=#SDATA          ;
  B=C_DATA (A)       ;
  DACS0=[HL+B] (A)  ;
  SET1  TCE1         ; Enables 8-bit timer 1 operation
  CLR1  TMIF1        ; Clears 8-bit timer 1 request flag
  CLR1  TMMK1        ; Enables 8-bit timer 1 interrupt
  SET1  DACE0        ; Enables D/A operation
endif
      :
      :

```

(3) SPD chart





(4) Program list

```

PUBLIC  C_DATA,SDATA,ENDDAT
;
VETIM1  CSEG      AT 24H
        DW        INTTM1

ENDDAT   EQU      1DH                                ; SIN wave data 1 cycle end value
;
SINRAM   DSEG      SADDR
C_DATA:  DS        1                                ; ROM data counter
;*****
;      SIN wave data change interrupt processing
;*****
SINDAT   CSEG
INTTM1:
        SEL      RB3                                ; Sets bank 3
        C_DATA++                                ; Increments ROM data counter
        B=C_DATA (A)                            ; Refers to SIN wave output data
        HL=#SDATA
        DACS0=[HL+B] (A)                        ; Stores data
        if(C_DATA >= #ENDDAT)                  ; End of 1 cycle of SIN wave?
            C_DATA=#0FFH                        ;   Initializes ROM data counter
        endif
        RETI
SDATA:
        DB      09BH                                ; SIN wave data
        DB      0B4H
        DB      0CBH
        DB      0DFH
        DB      0EFH
        DB      0FAH
        DB      0FFH
        DB      0FFH
        DB      0FAH
        DB      0EFH
        DB      0DFH
        DB      0CBH
        DB      0B4H
        DB      09BH
        DB      080H
        DB      065H
        DB      04CH
        DB      035H
        DB      021H
        DB      011H
        DB      006H
        DB      001H
        DB      001H
        DB      006H
        DB      011H
        DB      021H
        DB      035H
        DB      04CH
        DB      065H
        DB      080H
        END
    
```

[MEMO]

## CHAPTER 11 APPLICATION OF REAL-TIME OUTPUT PORT

This chapter describes the real-time output function of the 78K/0 series.

The real-time output function is used to output data set in advance in the real-time output buffer registers (RTBL and RTBH) to an external device by transferring the data to an output latch by hardware as soon as a timer interrupt request or external interrupt request occurs.

By using the real-time output port function, a jitter free signal can be output. Therefore, this function is ideal for controlling a stepping motor. The real-time output port can be set in the port mode or real-time output mode in 1-bit units.

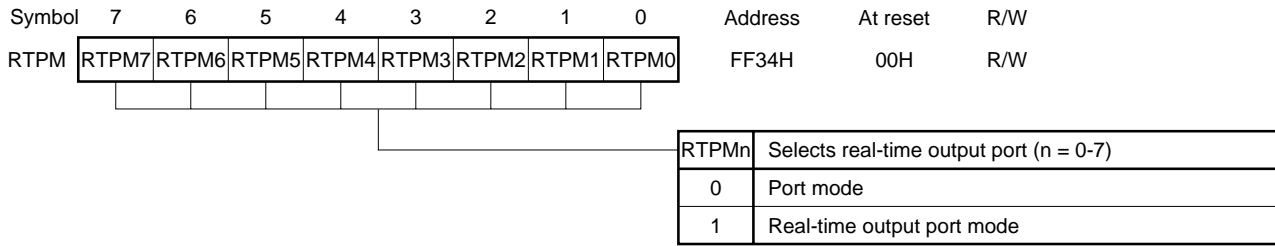
The real-time output data is written to the real-time output buffer registers (RTBL and RTBH). RTBL and RTBH are mapped to independent addresses in the SFR area.

When an operation mode of 4 bits  $\times$  2 channels is selected, RTBL and RTBH can independently set data.

When an operation mode of 8 bits  $\times$  1 channel is specified, data can be set to RTBL or RTBH by writing 8-bit data to either of RTBL or RTBH.

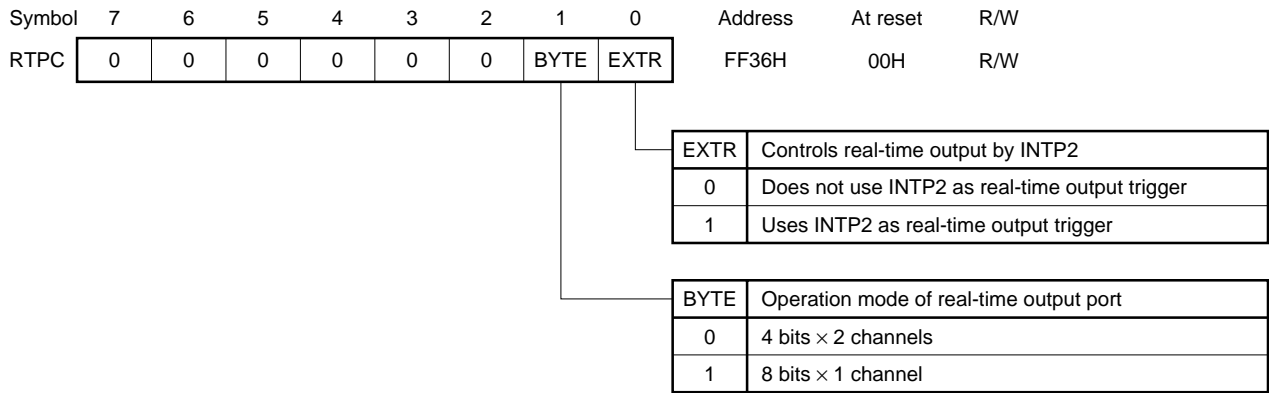
The real-time output port is set by using the real-time output port mode register (RTPM), real-time output control register (RTPC), and port mode register 12 (PM12).

Figure 11-1. Format of Real-Time Output Port Mode Register



- Cautions**
1. When the real-time output port mode is used, the port that performs real-time output must be set in the output mode (by clearing the corresponding bits of the port mode register 12 (PM12) to 0).
  2. Data cannot be set to the output latch of the port set in the real-time output port mode. To set an initial value, therefore, set data to the output latch before setting the real-time output port mode.

Figure 11-2. Format of Real-Time Output Port Control Register



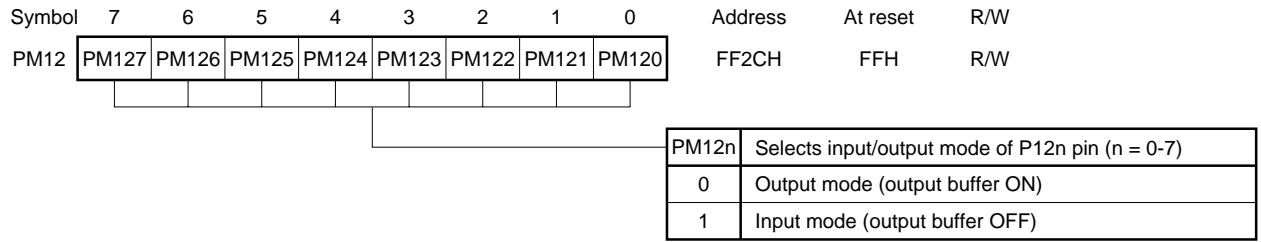
The relationship between operation mode and output trigger of the real-time output port is shown in Table 11-1.

Table 11-1. Operation Mode and Output Trigger of Real-Time Output Port

| BYTE | EXTR | Output Mode         | RTBH → Port Output | RTBL → Port Output |
|------|------|---------------------|--------------------|--------------------|
| 0    | 0    | 4 bits × 2 channels | INTTM2             | INTTM1             |
|      | 1    |                     | INTTM1             | INTP2              |
| 1    | 0    | 8 bits × 1 channel  | INTTM1             |                    |
|      | 1    |                     | INTP2              |                    |

★

Figure 11-3. Format of Port Mode Register 12



### 11.1 Stepping Motor

A 4-phase stepping motor is connected to the real-time output port (P120 through P123) and is controlled with 1-phase excitation pattern. A motor that rotates 1.8 degree per step is used for 1-phase excitation and is driven 200 revolutions per minute.

The time required for 1 step is calculated by the following expression:

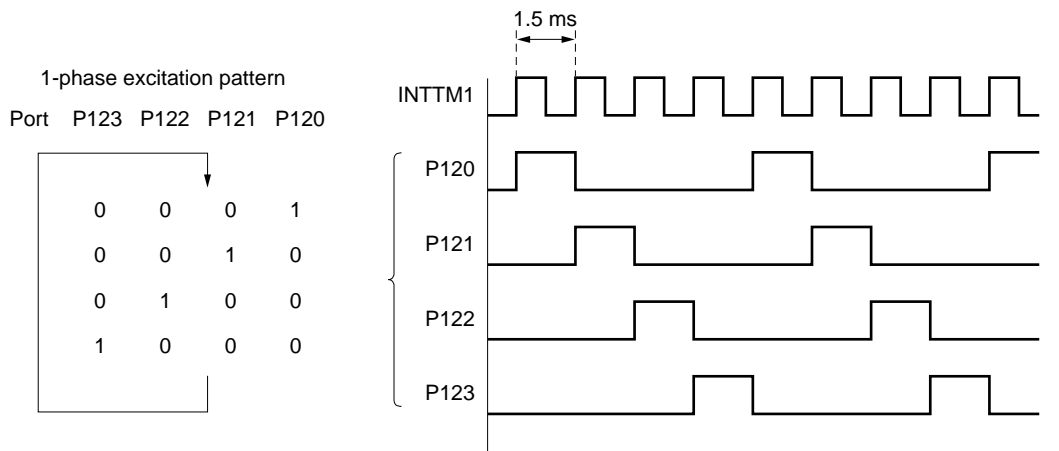
$$1 \text{ step} = \frac{60 \text{ seconds}}{200 \text{ revolutions} \times \frac{360 \text{ degrees}}{1.8 \text{ degree}} \text{ Step}} = 1.5 \text{ ms}$$

The compare register (CR01) of 8-bit timer/event counter 1 is set to 1.5 ms and the real-time output buffer register (RTBL) is set.

By using the real-time output port control register (RTPC), set the 4 bit × 2 channel real-time output mode, and the coincidence interrupt (INTTM1) of the 8-bit timer/event counter 1 as the output trigger (refer to **Table 11-1**).

Figure 11-4 shows the phase excitation output pattern and output timing.

**Figure 11-4. Phase Excitation Output Pattern and Output Timing**



**(1) Description of package****<Public declaration symbol>**

None

**<Register used>**

Bank 3, A

**<RAM used>**

None

**<Flag used>**

None

**<Nesting level>**

1 level 3 bytes

**<Hardware used>**

- Real-time output port
- 8-bit timer/event counter 1

**<Initial setting>**

- OSMS = #00000001B ; Oscillation mode select register: does not use divider circuit
- P12 = #xxxx0000B ; Sets P120-P123 in output port mode  
PM12 = #xxxx0000B
- TCL1 = #xxxx1010B ; Timer clock select register 1 (count clock: 131 kHz)
- CR10 = #195 ; Compare register (set to 1.5 ms)
- TMC1 = #000000x1B ; 8-bit timer mode control register 1 (enables operation of 8-bit timer/event counter 1)
- RTPM = xxxx1111B ; Real-time output port mode register (lower 4 bits are used as real-time output port)
- RTPC = #00000000B ; Real-time output port control register (selects 4 bit × 2 channel mode and INTTM1 as output trigger)
- RTBL = #00000001B ; Initial setting of real-time output buffer register
- CLR1 TMIF1 ; Clears 8-bit timer/event counter 1 interrupt request flag
- CLR1 TMMK1 ; Enables 8-bit timer/event counter 1

**<Starting>**

Clear the interrupt request flag of 8-bit timer/event counter 1 and enable the interrupt when the operation is started.

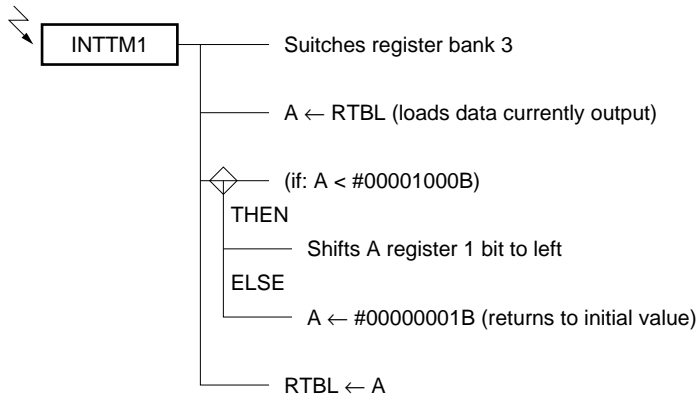
(2) Example of use

```

:
OSMS=#00000001B
TCL1=#00001010B           ; Does not use divider circuit
CR10=#196-1               ; MORTER_DAT: 8-bit timer 1. Count clock: 131 kHz
P12=#00000000B           ; Sets compare register to 1.5 ms
PM12=#11110000B          ;
RTPM=#00001111B          ; Sets P120-P123 in output port mode
RTPC=#00000000B          ; Sets low-order 4 bits in output port mode
RTBL=#00000001B          ; Uses INTTM1 as output trigger
TMC1=#00000001B          ;
CLR1    TMIF1             ; Enables 8-bit timer 1 operation
CLR1    TMMK1             ; Clears 8-bit timer 1 interrupt request flag
EI                               ; Enables 8-bit timer 1 interrupt
:

```

(3) SPD chart



(4) Program list

```

VETIM1    CSEG    AT 24H
          DW      INTTM1
;*****
;          Stepping motor data output processing
;*****
MOTER     CSEG
INTTM1:
    SEL    RB3                ; Bank 3
    A=RTBL                    ;
    if(A < #8)                ; Prepares next output data
        A <<= 1                ;
    else                        ;
        A=#01H                ;
    endif                      ;
    RTBL=A                    ; RTPL ← output data
    RETI                       ;
    END

```



## CHAPTER 12 APPLICATIONS OF LCD CONTROLLER/DRIVER

The LCD controller/driver of the  $\mu$ PD78064, 78064Y, 780308, 780308Y, and 78064B subseries is set by using the LCD display mode register (LCDM) and LCD display control register (LCDC).

**Figure 12-1. Format of LCD Display Mode Register**  
( $\mu$ PD78064, 78064Y, 78064B subseries)

|        |       |       |       |       |   |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|---|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3 | 2     | 1     | 0     | Address | At reset | R/W |
| LCDM   | LCDON | LCDM6 | LCDM5 | LCDM4 | 0 | LCDM2 | LCDM1 | LCDM0 | FFB0H   | 00H      | R/W |

| LCDM2  | LCDM1 | LCDM0 | Time division      | Bias |
|--------|-------|-------|--------------------|------|
| 0      | 0     | 0     | 4                  | 1/3  |
| 0      | 0     | 1     | 3                  | 1/3  |
| 0      | 1     | 0     | 2                  | 1/2  |
| 0      | 1     | 1     | 3                  | 1/2  |
| 1      | 0     | 0     | Static             |      |
| Others |       |       | Setting prohibited |      |

| LCDM6  | LCDM5 | LCDM4 | Selects LCD clock <sup>Note</sup> |                        |                          |
|--------|-------|-------|-----------------------------------|------------------------|--------------------------|
|        |       |       | At $f_{xx} = 5.0$ MHz             | At $f_{xx} = 4.19$ MHz | At $f_{XT} = 32.768$ kHz |
| 0      | 0     | 0     | $f_w/2^9$ (76 Hz)                 | $f_w/2^9$ (64 Hz)      | $f_w/2^9$ (64 Hz)        |
| 0      | 0     | 1     | $f_w/2^8$ (153 Hz)                | $f_w/2^8$ (128 Hz)     | $f_w/2^8$ (128 Hz)       |
| 0      | 1     | 0     | $f_w/2^7$ (305 Hz)                | $f_w/2^7$ (256 Hz)     | $f_w/2^7$ (256 Hz)       |
| 0      | 1     | 1     | $f_w/2^6$ (610 Hz)                | $f_w/2^6$ (512 Hz)     | $f_w/2^6$ (512 Hz)       |
| Others |       |       | Setting prohibited                |                        |                          |

| LCDON | Enables/disables LCD display                                  |
|-------|---|
| 0     | Display off (all segment outputs are unselect signal outputs) |
| 1     | Display on  |

**Note** The LCD clock is supplied by the watch timer. To perform LCD display, set the bit 1 (TMC21) of watch timer mode control register (TMC2) to 1.  
If TMC21 is reset to 0 during LCD display, supply of the LCD clock is stopped and the display is disturbed.

- Remarks**
1.  $f_w$  : watch timer clock frequency ( $f_{xx}/2^7$  or  $f_{XT}$ )
  2.  $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  3.  $f_x$  : main system clock oscillation frequency
  4.  $f_{XT}$  : subsystem clock oscillation frequency

★

**Figure 12-2. Format of LCD Display Mode Register  
( $\mu$ PD780308, 780308Y subseries)**

|        |       |       |       |       |       |       |       |       |         |          |     |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|---------|----------|-----|
| Symbol | 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     | Address | At reset | R/W |
| LCDM   | LCDON | LCDM6 | LCDM5 | LCDM4 | LCDM3 | LCDM2 | LCDM1 | LCDM0 | FFB0H   | 00H      | R/W |

| LCDM2  | LCDM1 | LCDM0 | Time division      | Bias |
|--------|-------|-------|--------------------|------|
| 0      | 0     | 0     | 4                  | 1/3  |
| 0      | 0     | 1     | 3                  | 1/3  |
| 0      | 1     | 0     | 2                  | 1/2  |
| 0      | 1     | 1     | 3                  | 1/2  |
| 1      | 0     | 0     | Static             |      |
| Others |       |       | Setting prohibited |      |

| Note 1<br>LCDM3 | Operation mode of LCD controller/driver | Supply voltage of LCD controller/driver |               |               |
|-----------------|---|---|---------------|---------------|
|                 |   | Static display mode                     | 1/3 bias mode | 1/2 bias mode |
| 0               | Normal operation                        | 2.0 to 5.5 V                            | 2.5 to 5.5 V  | 2.7 to 5.5 V  |
| 1               | Low-voltage operation                   | 2.0 to 3.4 V                            |               |               |

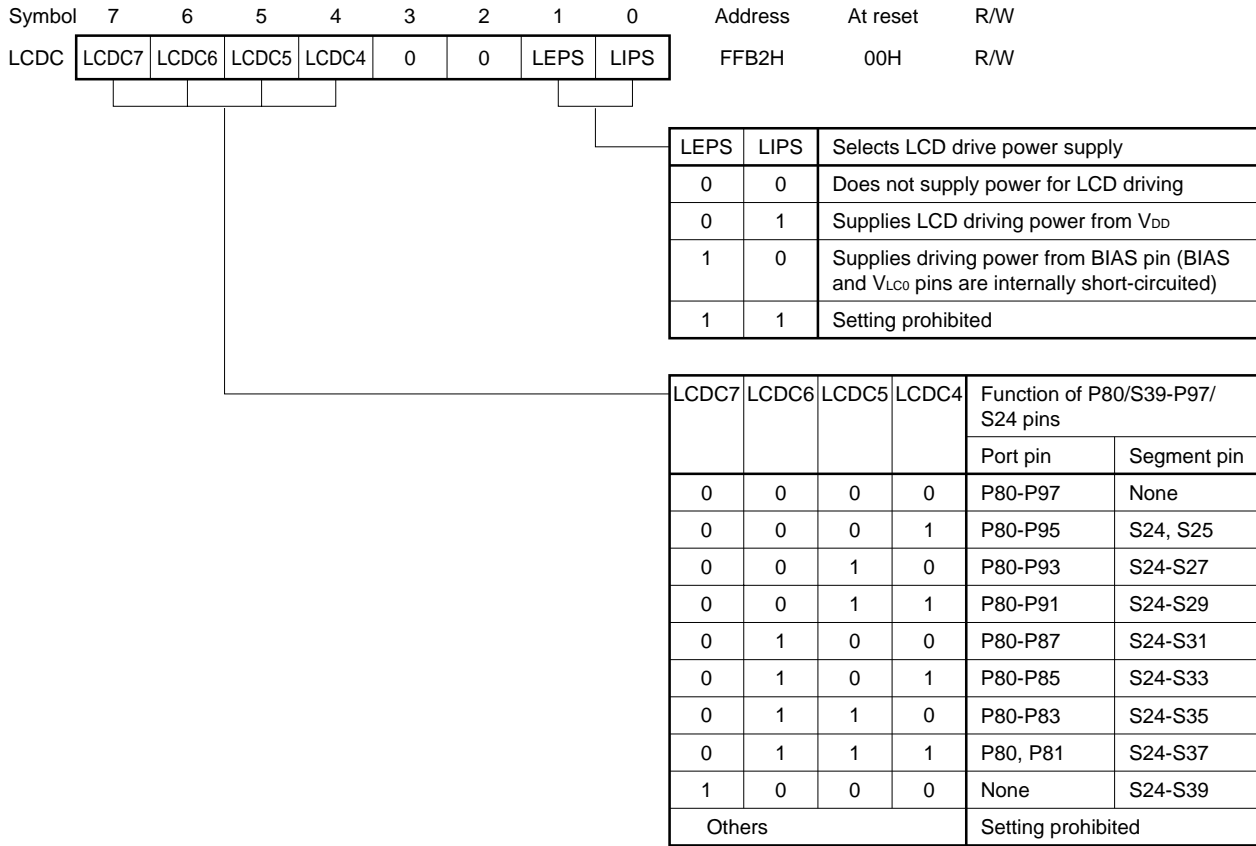
| LCDM6  | LCDM5 | LCDM4 | Selects LCD clock <sup>Note</sup> |                        |                          |
|--------|-------|-------|-----------------------------------|------------------------|--------------------------|
|        |       |       | At $f_{xx} = 5.0$ MHz             | At $f_{xx} = 4.19$ MHz | At $f_{XT} = 32.768$ kHz |
| 0      | 0     | 0     | $f_w/2^9$ (76 Hz)                 | $f_w/2^9$ (64 Hz)      | $f_w/2^9$ (64 Hz)        |
| 0      | 0     | 1     | $f_w/2^8$ (153 Hz)                | $f_w/2^8$ (128 Hz)     | $f_w/2^8$ (128 Hz)       |
| 0      | 1     | 0     | $f_w/2^7$ (305 Hz)                | $f_w/2^7$ (256 Hz)     | $f_w/2^7$ (256 Hz)       |
| 0      | 1     | 1     | $f_w/2^6$ (610 Hz)                | $f_w/2^6$ (512 Hz)     | $f_w/2^6$ (512 Hz)       |
| Others |       |       | Setting prohibited                |                        |                          |

| LDON | Enables/disables LCD display                                  |
|------|---|
| 0    | Display off (all segment outputs are unselect signal outputs) |
| 1    | Display on  |

- Notes**
- To lower the power consumption, clear LCDM3 to 0 when LCD display is not used. To manipulate LCDM3, be sure to turn off the LCD display.  
If TMC21 is cleared to 0 during LCD display, the supply of the LCD clock is stopped and the display is disturbed.
  - The LCD clock is supplied by the watch timer. To perform LCD display, set the bit 1 (TMC21) of watch timer mode control register (TMC2) to 1.  
If TMC21 is reset to 0 during LCD display, supply of the LCD clock is stopped and the display is disturbed.

- Remarks**
- $f_w$  : watch timer clock frequency ( $f_{xx}/2^7$  or  $f_{XT}$ )
  - $f_{xx}$  : main system clock frequency ( $f_x$  or  $f_x/2$ )
  - $f_x$  : main system clock oscillation frequency
  - $f_{XT}$  : subsystem clock oscillation frequency

Figure 12-3. Format of LCD Display Control Register



- Cautions**
1. Pins that output segments cannot be used as output port pins even if 0 is set to the corresponding port mode register.
  2. When pins that output segments are read as port pins, 0 is returned.
  3. Pins set by LCDC to output segments are not used with the internal pull-up resistor, regardless of the values of the bits 0 and 1 (PU08 and PU09) of the pull-up resistor option register H (PUOH).

The LCD controller/driver of the  $\mu$ PD78064, 78064Y, 780308, and 780308Y subseries is described next.

**(a) Function of LCD controller/driver**

The LCD controller/driver has the following functions:

- <1> Automatically outputs segment and common signals by automatically reading the display data memory.
- <2> Five types of display modes are available:
  - Static mode
  - 1/2 duty mode (1/2 bias)
  - 1/3 duty mode (1/2 bias)
  - 1/3 duty mode (1/3 bias)
  - 1/4 duty mode (1/3 bias)
- <3> Four types of frame frequencies can be selected in each display mode.
- <4> Up to 40 segment signal outputs (S0 through S39) and four common signal outputs (COM0 through COM3) are available. Sixteen segment outputs can be set in the input/output port mode in 2-bit units (P80/S39 through P87/S32, and P90/S31 through P97/S24).
- <5> Divider resistors for generating the LCD drive voltage can be provided to the mask ROM model by mask option.
- <6> Can operate on the subsystem clock.

Table 12-1 shows the maximum number of pixels that can be displayed in each display mode.

**Table 12-1. Maximum Number of Pixels for Display**

| Bias | Time Division | Common Signal Used | Maximum Number of Pixels                              |
|------|---------------|--------------------|---|
| –    | Static        | COM0 (COM0-COM3)   | 40 (40 segments $\times$ 1 common) <sup>Note 1</sup>  |
| 1/2  | 2             | COM0, COM1         | 80 (40 segments $\times$ 2 common) <sup>Note 2</sup>  |
|      | 3             | COM0-COM2          | 120 (40 segments $\times$ 3 common) <sup>Note 3</sup> |
| 1/3  | 3             | COM0-COM2          |   |
|      | 4             | COM0-COM3          | 160 (40 segments $\times$ 4 common) <sup>Note 4</sup> |

- Notes**
1. Can display 5 digits with eight segments for each digit on an 8-segment LCD panel.
  2. Can display 10 digits with four segments for each digit on an 8-segment LCD panel.
  3. Can display 13 digits with three segments for each digit on an 8-segment LCD panel.
  4. Can display 20 digits with two segments for each digit on an 8-segment LCD panel.

**(b) Setting of LCD controller/driver**

Set the LCD controller/driver as follows. When using the LCD controller/driver, set the watch timer in the operating status in advance.

- <1> Enables the watch operation by using the timer clock select register 2 (TCL2) and watch timer mode control register (TMC2).
- <2> Set the initial value to the display data memory (FA58H through FA7FH).
- <3> Specify the pins used for segment output by using the LCD display control register (LCDC).
- <4> Set the display mode and LCD clock by using the LCD display mode register.

After that, set data to the display data memory according to the contents to be displayed.

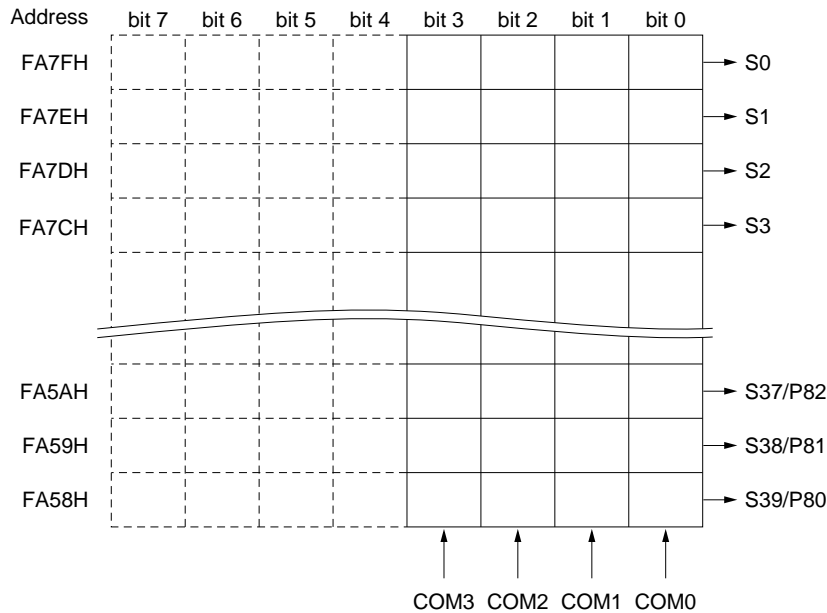
**(c) LCD display data memory**

The LCD display data memory is mapped to addresses FA58H through FA7FH. The data stored to the LCD display data memory can be displayed on the LCD panel by using the LCD controller/driver.

Figure 12-4 shows the relations between the contents of LCD display data memory and the segment/common outputs.

The area not used for display can be used as an ordinary RAM area.

**Figure 12-4. Relations between Contents of LCD Display Data Memory and Segment/Common Output**



**Caution** The high-order 4 bits of the LCD display data memory are not used as memory bits. Be sure to clear these bits to 0.

**(d) Common and segment signals**

Each pixel on an LCD panel lights when the potential difference between the corresponding common and segment signals reaches to a specific level (LCD drive voltage  $V_{LCD}$ ).






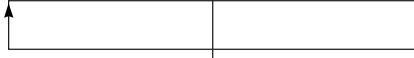


Because an LCD panel degrades if DC voltages are applied as common and segment signals, it is driven by AC voltages.

**<1> Common signal**

The common signal is selected as shown in Table 12-2 according to the set number of time divisions and repeatedly operates in the cycles shown in the table. In the static mode, the same signal is output to COM0 through COM3.

In the 2-time division mode, open the COM2 and COM3 pins. Open the COM3 pin in the 3-time division mode.

**Table 12-2. COM Signal**

| COM Signal<br>Number of Time Divisions | COM0   | COM1  | COM2  | COM3  |
|--|--|---|---|---|
| Static                                 |     |  |    |  |
| 2 time divisions                       |     |   | Open  | Open  |
| 3 time divisions                       |   |   |  | Open  |
| 4 time divisions                       |  |   |   |   |

**<2> Segment signal**

Segment signals correspond to a 40-byte LCD display data memory (FA58H through FA7FH). Bits 0, 1, 2, and 3 of the display data memory are read in synchronization of COM0, COM1, COM2, and COM3, respectively. If the content of each bit is 1, the corresponding segment signal is converted to a select voltage and is output to the segment pin (S0 to S39). If the content of a bit is 0, the segment signal is converted to an unselect voltage. (Note that S24 through S39 are multiplexed with input/output port pins.) Therefore, confirm what combination of the front panel electrode (corresponding to a segment signal) and rear panel electrode (corresponding to a common signal) of the LCD panel generates a display pattern, and write the bit data corresponding to the pattern to be displayed on a one-to-one basis to the LCD display memory.

In the static mode, bits 1, 2, and 3 of the LCD display data memory are not used for LCD display. In the 2- and 3-time division modes, bits 2 and 3, and bit 3 are not used for LCD display, respectively. These bits therefore can be used for any other purposes.

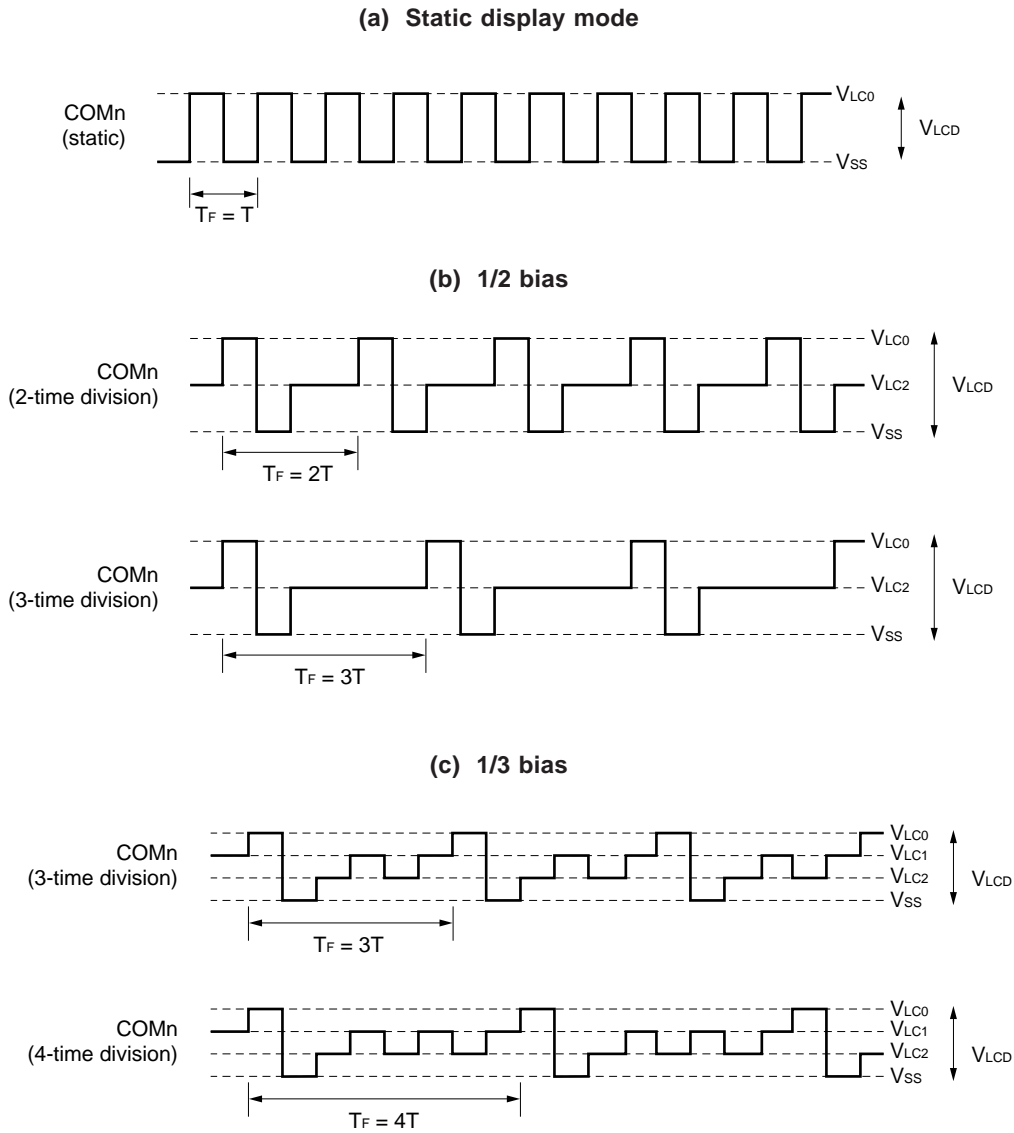
Bits 4 through 7 are fixed to 0.

<3> Output waveforms of common and segment signals

Only when the voltage levels of specific common and segment signals reach the select levels,  $\pm V_{LCD}$  (LCD drive voltage) level is reached and the corresponding pixel on the LCD panel lights. The pixel remains dark with any other combination of the common and segment signals.

Figure 12-5 shows the waveform of the common signals, and Figure 12-6 shows the phase difference in voltage between the common and segment signals.

Figure 12-5. Common Signal Waveform

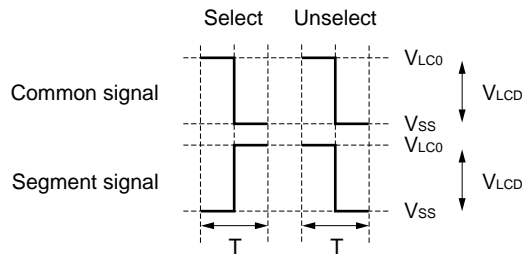


- Remarks**
1.  $T$  : one cycle of LCDCL
  2.  $T_F$  : frame frequency
  3.  $V_{LCD}$  : LCD drive voltage

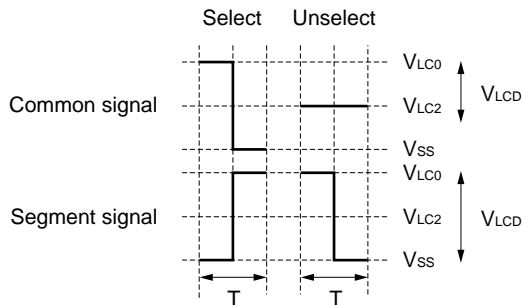


Figure 12-6. Phase Difference in Voltage between Command Signal and Segment Signal

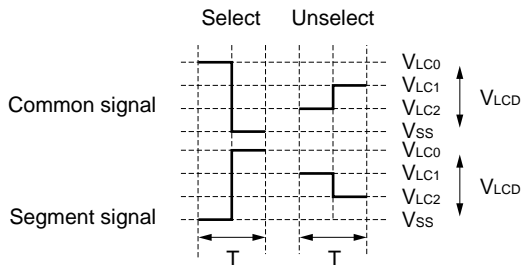
(a) Static display mode



(b) 1/2 bias



(c) 1/3 bias



- Remarks 1. T : one cycle of LCDCL
- 2.  $V_{LCD}$  : LCD drive voltage

(e) Supplying LCD drive voltage

The mask ROM model can be provided by mask option with a divider resistor that is used to create the LCD drive voltage (the PROM model is not provided with a divider resistor). By providing the divider resistor, an LCD drive voltage corresponding to each bias can be created without an external divider resistor. In addition, an LCD drive voltage can be supplied to the BIAS pin to support various LCD drive voltages.

### 12.1 Static Display

This section explains an example using the  $\mu$ PD78064 subseries. A 4-digit static LCD is driven by using the 32 segment signals (S0 through S31) and a common signal (COM0). Figure 12-7 shows the display pattern and electrode wiring of static LCD. Figure 12-8 shows the connections among the segment signals and common signal. Figure 12-9 shows an example of connecting an LCD driving power supply in the static display mode (with an external divider resistor,  $V_{DD} = 5\text{ V}$ , and  $V_{LCD} = 5\text{ V}$ ). The display example in Figure 12-8 is “1234”, and the contents of the display data memory (addresses FA60H through FA7FH) correspond to this.

In this section, how to display the second digit, “3”, is described. According to the display pattern in Figure 12-8, the select and unselect voltages must be output to the S8 through S15 pins in the timing of the common signal COM0, as shown in Table 12-3.

**Table 12-3. Select and Unselect Voltages (COM0)**

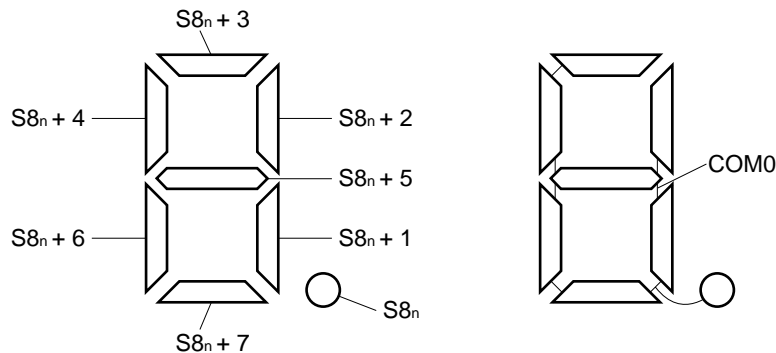
| Segment<br>Common | S8       | S9     | S10    | S11    | S12      | S13    | S14      | S15    |
|-------------------|----------|--------|--------|--------|----------|--------|----------|--------|
| COM0              | Unselect | Select | Select | Select | Unselect | Select | Unselect | Select |

From Table 12-3, it is clear that 10101110 must be set to bit 0 of the display data memory (addresses FA70H through FA77H) corresponding to S8 through S15.

Figure 12-10 shows the LCD driving waveforms of S11, S12, and COM0.

Because the same waveform as COM0 is output to COM1, 2, and 3, the driving capability can be increased by connecting COM0, 1, 2, and 3.

**Figure 12-7. Display Pattern and Electrode Wiring of Static LCD**



**Remark** n = 0-3

Figure 12-8. Connection of Static LCD

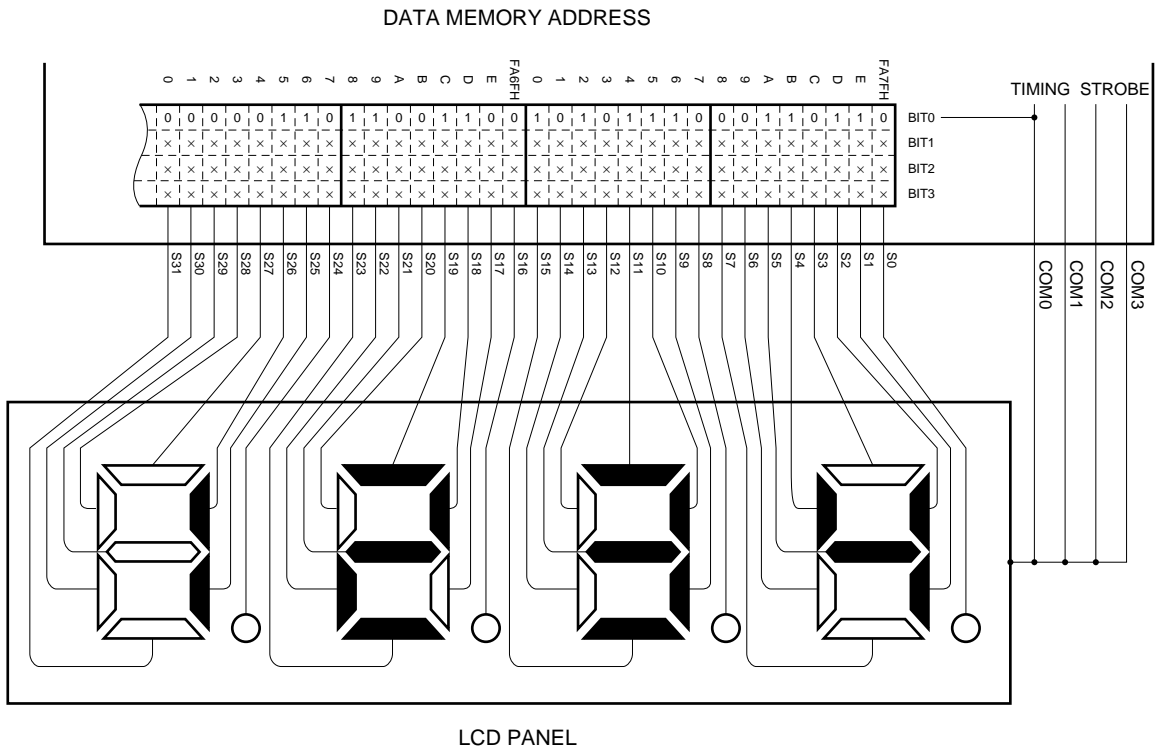


Figure 12-9. Example of Connecting LCD Driving Power in Static Display Mode (with external divider resistor,  $V_{DD} = 5\text{ V}$ , and  $V_{LCD} = 5\text{ V}$ )

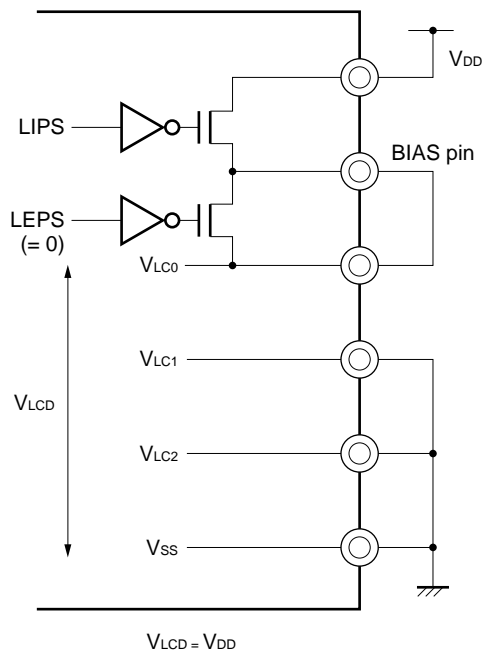
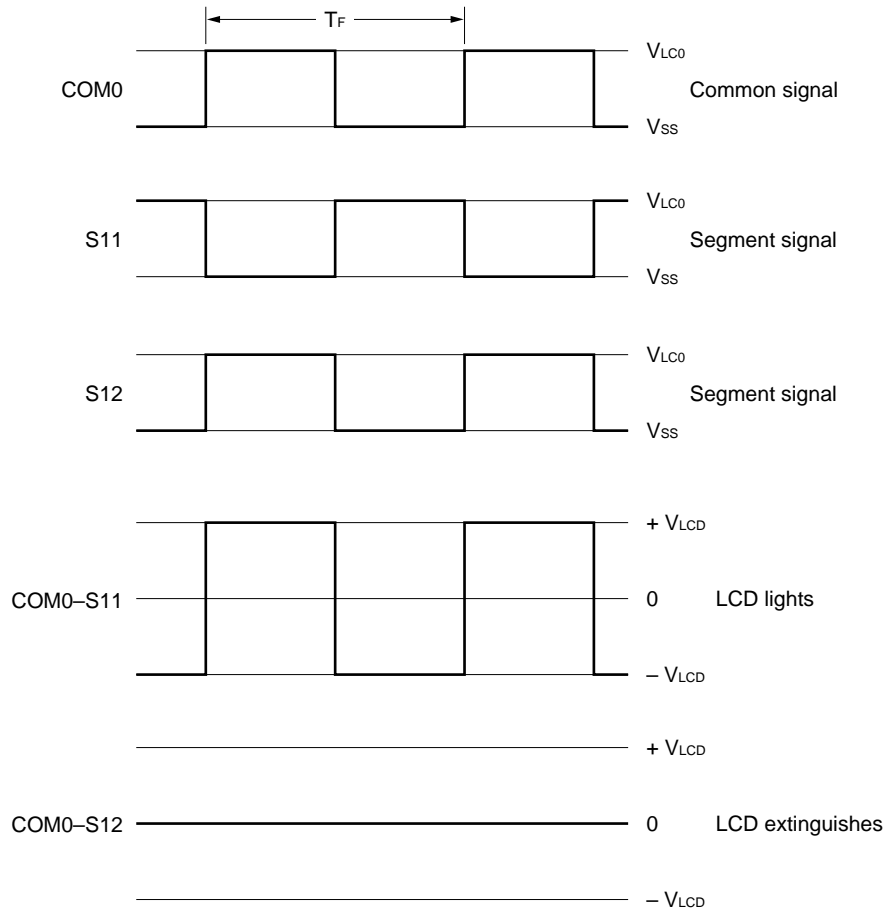


Figure 12-10. Example of Static LCD Driving Waveform



**Remark**  $T_F$ : frame frequency

To display the LCD, segment signals are output based on the waveform of the common signal.

The static LCD is lit by a segment signal (S11) output at a frame frequency half a cycle shifted from that of the common signal (COM0) as shown in Figure 12-10. This means that a potential difference is generated between the common signal and segment signal, and this potential difference is responsible for lighting the LCD. As can be seen from COM0 and S11 in Figure 12-10, a potential difference  $\pm V_{LCD}$  (LCD drive voltage) is generated between these signals.

To extinguish the LCD, the segment signal (S12) is output in a waveform synchronous to that of the common signal (COM0). In this way, the potential difference between COM0 and S12 is eliminated and the LCD remains dark.

**(1) Description of package****<Public declaration symbol>**

- Subroutine name  
S\_LCD : Static display data storage routine
- Input parameter  
B\_LCD : LCD display content storage buffer area
- Data definition reference name  
S0 : LCD display data memory reference address (FA7FH)

**<Register used>**

Bank 0 : AX, DE, HL

**<RAM used>**

| Name  | Usage   | Attribute | Bytes |
|-------|---|-----------|-------|
| B_LCD | LCD display data storage buffer area          | SADDR     | 1     |
| i     | Display digit loop counter                    | SADDR     | 1     |
| j     | Segment setting loop counter                  | SADDR     | 1     |
| WORKP | Display data storage area address saving area | SADDRP    | 2     |

**<Flag used>**

None

**<Nesting level>**

1 level 2 bytes

**<Hardware used>**

- LCD controller/driver

**<Initial setting>**

- OSMS = #00000001B ; Oscillation mode select register
- TCL2 = #xxx00xxxB ; Count clock of watch timer = selects system clock
- TMC2 = #0xxxxx1xB ; Supplies LCD clock (enables prescaler operation)
- LCDC = #01000010B ; LCD display control register (supplies LCD drive power from BIAS pin with segment pins S24 through S31 used)
- LCDM = #10100100B ; LCD display mode register (sets static display, selects LCD clock, and turns on display)

**Caution** Set the initial value to the LCD display data memory (FA58H through FA7FH) before turning on the LCD display.

**<Starting>**

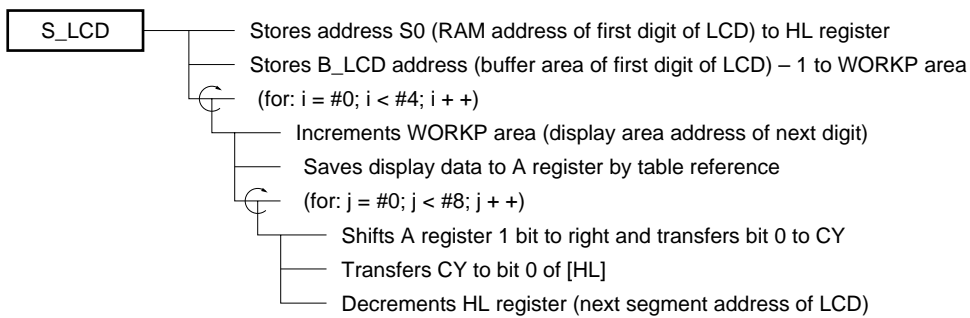
Set the display contents in the B\_LCD area and call the S\_LCD routine.

(2) Example of use

```

EXTRN    SLCD,B_LCD,S0
        :
        :
        HL=#S0                ; Clears LCDRAM
        BC=#0FA80H-0FA58H    ; (from FA58H to FA7FH)
        while(BC!=#0) (AX)  ;
            A=#0              ;
            [HL]=A            ;
            HL--              ;
            BC--              ;
        endw                  ;
;
        B_LCD=#0              ;
        B_LCD+1=#0           ;
        B_LCD+2=#0           ;
        B_LCD+3=#0           ;
;
        TCL2=#00000000B      ; Count clock of watch timer = selects main system clock
        TMC2=#00000010B      ; Enables operation of prescaler
        LCDC=#01000010B      ; Supplies LCD drive power from BIAS pin with segments S24 through 31 used
        LCDM=#10100100B      ; Turns ON static display with 256-Hz clock selected
;
        :
        B_LCD+3=A            ;
        :
        B_LCD+2=A            ;
        :
        B_LCD+1=A            ;
        :
        B_LCD=A              ;
        CALL    !S_LCD        ;
        :
    
```

(3) SPD chart



## (4) Program list

```

PUBLIC  S_LCD,B_LCD,S0
;
S0      EQU      0FA7FH          ; 1st digit of LCD
;
LCDRAM1  DSEG    SADDR
B_LCD:   DS      4              ; Display BUF area
i:       DS      1              ; Work counter
j:       DS      1              ; Work counter
LCDRAM2  DSEG    SADDRP
WORKP:   DS      2              ; Work area
;*****
;      LCD display (static display) processing
;*****
LSDS     CSEG
S_LCD:
    HL=#S0                      ; HL ← address S0
    WORKP=#B_LCD-1              ; Work area ← address of B_LCD - 1
    for(i=#0;i<#4;i++)
        DE=WORKP (AX)
        DE++                    ; References display data of contents of next digit
        WORKP=DE (AX)
        X=[DE] (A)
        A=#0
        AX+=#LCDDAT
        DE=AX
        A=[DE]
        for(j=#0;j<#8;j++)
            RORC  A,1            ; Stores display data to bit 0 from address S0
            [HL].0=CY
            HL--
        next
    next
    RET
LCDDAT:
    DB  11011110B              ; 0
    DB  00000110B              ; 1
    DB  11101100B              ; 2
    DB  10101110B              ; 3
    DB  00110110B              ; 4
    DB  10111010B              ; 5
    DB  11111010B              ; 6
    DB  00011110B              ; 7
    DB  11111110B              ; 8
    DB  10111110B              ; 9
    DB  01111110B              ; A
    DB  11110010B              ; B
    DB  11011000B              ; C
    DB  11100110B              ; D
    DB  11111000B              ; E
    DB  01111000B              ; F
    DB  00000000B              ; Extinguishes
END

```

### 12.2 4-Time Division Display

This section explains an example using the  $\mu$ PD78064 subseries. Four LCD digits are driven by means of 1/3 bias and 4-time division by using the 16 segment signals (S0 through S15) and four common signals (COM0 through COM3). Figure 12-12 shows the connection of a 4-time division 4-digit LCD panel with 10 display patterns shown in Figure 12-11 and the segment (S0 through S15) and common (COM0 through COM4) signals of the  $\mu$ PD78064 subseries. Figure 12-13 shows an example of connecting an LCD drive power supply in the 4-time division display mode (with external divider resistor,  $V_{DD} = 5\text{ V}$ , and  $V_{LCD} = 5\text{ V}$ ). The display example in Figure 12-12 is “12345678”, and the contents of the display data memory (addresses FA70H through FA7FH) correspond to this.

In this case, “6” at the third digit has been taken as an example. According to the display pattern in Figure 12-12, the select and unselect voltages shown in Table 12-4 must be output to the S4 and S5 pins in the timing of the common signals COM0 through COM3.

**Table 12-4. Select and Unselect Voltages (COM0, 1, 2, 3)**

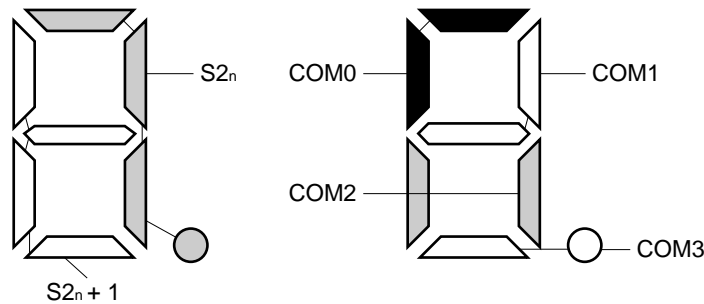
| Segment | S4           | S5         |
|---------|--------------|------------|
| Common  |              |            |
| COM0    | Select (a)   | Select (e) |
| COM1    | Unselect (b) | Select (f) |
| COM2    | Select (c)   | Select (g) |
| COM3    | Unselect (d) | Select (h) |

**Remark** (a) through (h) in the table corresponds to the segments a through h in Figure 12-12.

Table 12-4 indicates that 0101 should be stored to the display data memory address (FA7BH) corresponding to S4.

Figure 12-14 shows the LCD drive waveforms between S4 and COM0 and COM1 signals.

**Figure 12-11. Display Pattern of 4-Time Division LCD and Electrode Wiring**



**Remark**  $n = 0-7$



Figure 12-12. Connections of 4-Time Division LCD Panel

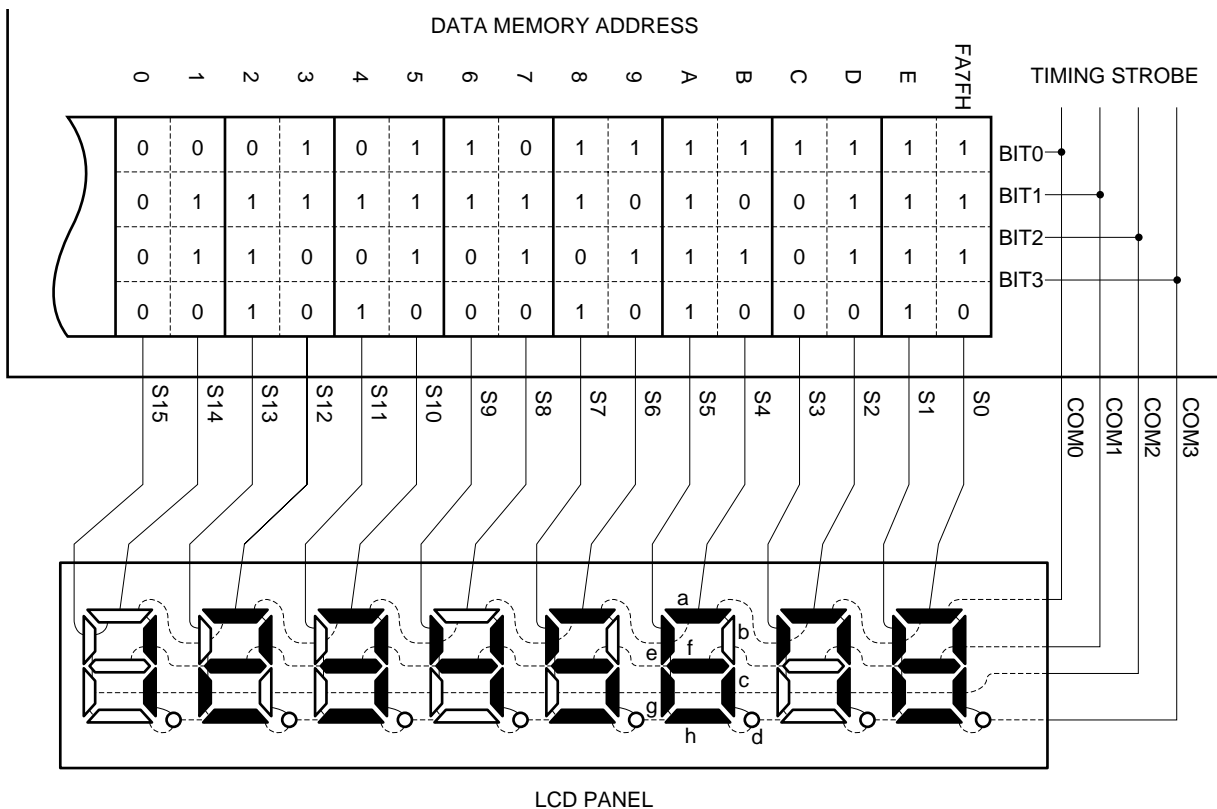


Figure 12-13. Example of Connecting LCD Drive Power in 4-Time Division Mode (with external divider resistor,  $V_{DD} = 5\text{ V}$ ,  $V_{LCD} = 5\text{ V}$ )

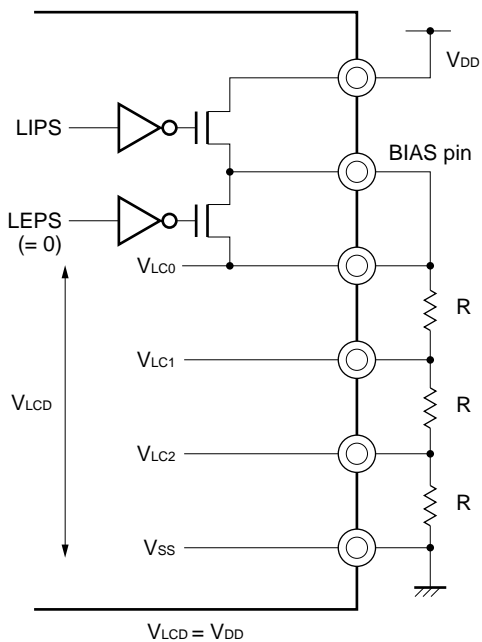
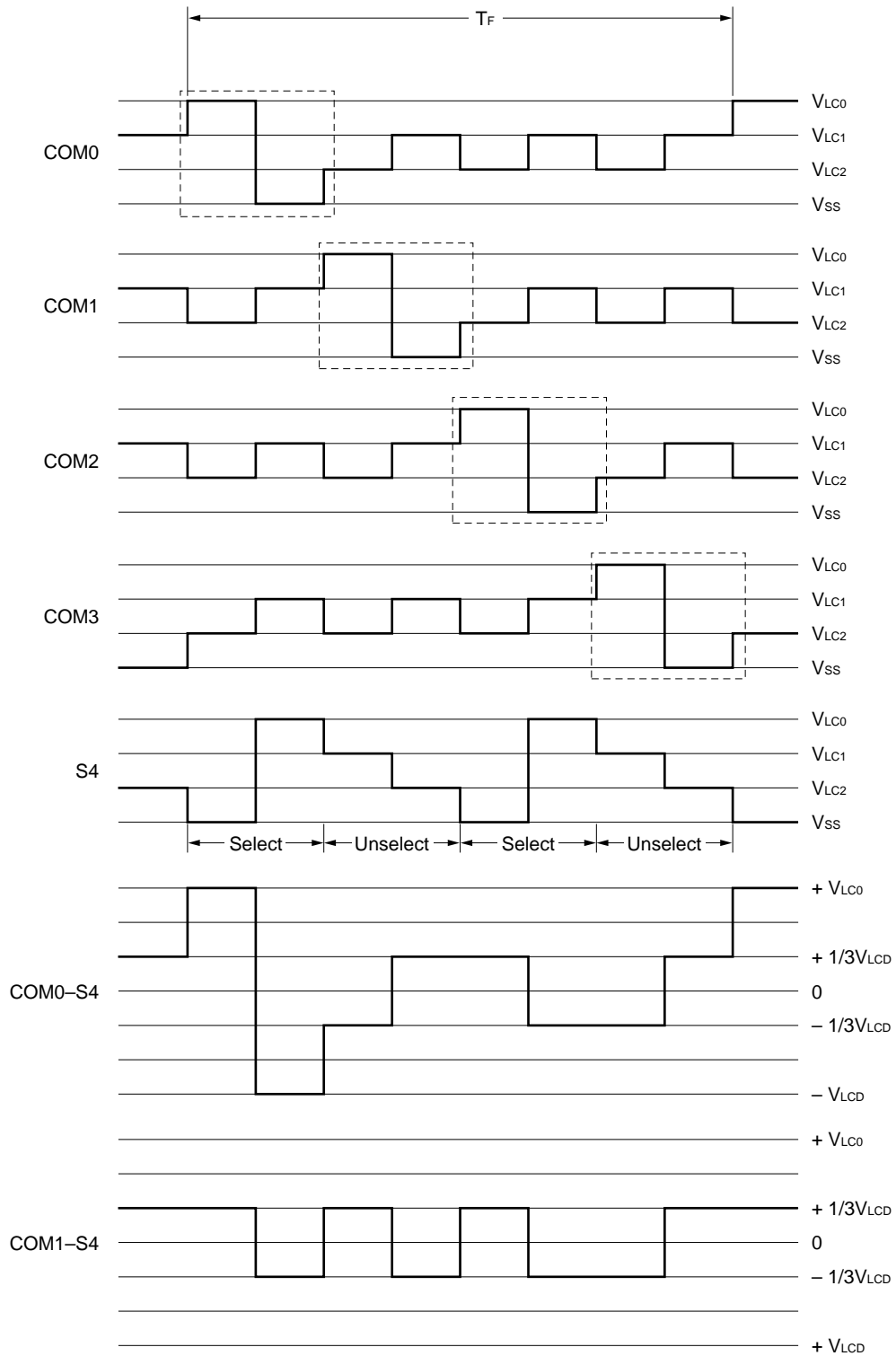


Figure 12-14. Example of 4-Time Division LCD Driving Waveform



- Remarks 1.**  $T_F$ : frame frequency  
**2.** The valid waveform of each common signal is enclosed in dotted line.

For 4-time division LCD display, the valid timing (enclosed in dotted line in Figure 12-14) of each common signal is output in a cycle  $1/4$  of the frame frequency ( $T_F$ ) as shown in Figure 12-14. In this timing, each segment signal is output to light or extinguish the LCD.

For example, segment signal S4 outputs a waveform that lights the LCD in the timing of COM0 and COM2, in respect to each common signal (COM0 through COM3) in Figure 12-14.

When the relations between each common signal and S4 is examined, it can be seen that a potential difference of  $\pm V_{LCD}$  (LCD drive voltage) is generated at the COM0 select timing between COM0 and S4, as can be seen from the waveform of COM0-S4. In the case of COM2 and S4, a voltage difference of  $\pm V_{LCD}$  (LCD drive voltage) is also generated between COM2 and S4 at the COM2 select timing. Therefore, the segment indicated by COM0, COM2 and S4 lights.

Because a voltage difference between COM1 and S4 is always  $\pm 1/3 V_{LCD}$  (COM1-S4 in Figure 12-14) at the select timing of COM1 (COM1 in Figure 12-14), the LCD remains dark.

**(1) Description of package****<Public declaration symbol>**

- Subroutine name  
S\_4LCD: 4-time division display data storage routine
- Input parameter  
B\_LCD : LCD display content storage buffer area
- Data definition reference name  
S0 : LCD display data memory reference address (FA7FH)

**<Register used>**

Bank 0; AX, DE, HL

**<RAM used>**

| Name  | Usage   | Attribute | Bytes |
|-------|---|-----------|-------|
| B_LCD | LCD display data storage buffer area          | SADDR     | 1     |
| i     | Display digit loop counter                    | SADDR     | 1     |
| WORKP | Display data storage area address saving area | SADDRP    | 2     |

**<Flag used>**

None

**<Nesting level>**

1 level 2 bytes

**<Hardware used>**

- LCD controller/driver

**<Initial setting>**

- OSMS = #00000001B ; Oscillation mode select register
- TCL2 = #xxx00xxxB ; Count clock of watch timer = selects system clock
- TMC2 = #0xxxxx1xB ; Supplies LCD clock (enables operation of prescaler)
- LCDC = #00000001B ; LCD display control register (LCD driving power is supplied from V<sub>DD</sub> with segment signal pins S24 through S31 not used)
- LCDM = #10100000B ; LCD display mode register (sets 4-time division display, selects LCD clock, turns ON display)

**Caution** Set the initial value to the LCD display data memory (FA58H through FA7FH) before turning ON the LCD.

**<Starting>**

Set the display contents to the B\_LCD area and call the S\_4LCD routine.

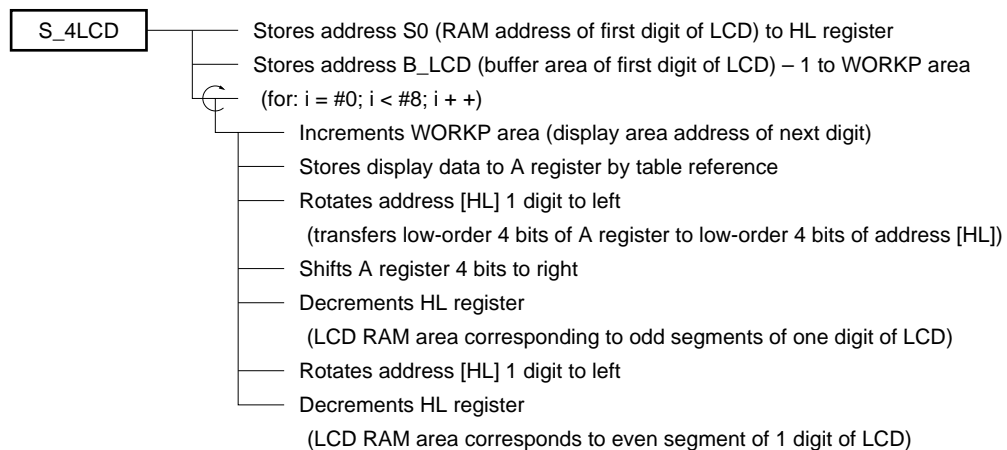
(2) Example of use

```

EXTRN    S_4LCD,B_LCD,S0
        :
        :
HL=#S0          ; Clears LCDRAM
BC=#0FA80H-0FA58H ; (from FA58H to FA7FH)
while(BC!=#0) (AX) ;
    A=#0 ;
    [HL]=A ;
    HL-- ;
    BC-- ;
endw ;
;
B_LCD=#0 ;
B_LCD+1=#0 ;
B_LCD+2=#0 ;
B_LCD+3=#0 ;
;
TCL2=#00000000B ; Count clock of watch timer = selects main system clock
TMC2=#00000010B ; Enables prescaler operation
LCDC=#00000001B ; Supplies driving power from VDD with segments S24 through S31 not used
LCDM=#10100000B ; Turns on 4-time division display with 256-Hz clock selected, turns ON display
;
        :
        B_LCD+3=A ;
        :
        B_LCD+2=A ;
        :
        B_LCD+1=A ;
        :
        B_LCD=A ;
CALL    !S_4LCD ;
        :

```

(3) SPD chart



(4) Program list

```

PUBLIC  S_4LCD,B_LCD,S0

S0      EQU      0FA7FH          ; 1st digit of LCD

LCD4RAM1  DSEG    SADDR
B_LCD:   DS      8              ; Display BUF area
i:       DS      1              ; Work counter
LCD4RAM2  DSEG    SADDRP
WO4RKP:  DS      2              ; Work area
;*****
;      LCD display (4-time division display) processing
;*****
LSD4     CSEG
S_4LCD:
    HL=#S0                      ; HL ← address S0
    WORKP=#B_LCD-1              ;
    for(i=#0;i<#8;i++)         ;
        DE=WORKP (AX)          ;
        DE++                    ; References display data of contents of next digit
        WORKP=DE (AX)          ;
        X=[DE] (A)             ;
        A=#0                    ;
        AX+=#LCDDAT            ;
        DE=AX                  ;
        A=[DE]                 ;
        ROL4 [HL]              ; [HL] ← low-order 4 bits of A register
        A >>= 1                ; Shifts high-order 4 bits of A register to lower 4 bits
        A >>= 1                ;
        A >>= 1                ;
        A >>= 1                ;
        HL--                    ; HL--
        ROL4 [HL]              ; [HL] ← low-order 4 bits of A register
        HL--                    ; HL--
    next
    RET                          ;
LCDDAT:
    DB 11010111B                ; 0
    DB 00000110B                ; 1
    DB 11100011B                ; 2
    DB 10100111B                ; 3
    DB 00110110B                ; 4
    DB 10110101B                ; 5
    DB 11110101B                ; 6
    DB 00010111B                ; 7
    DB 11110111B                ; 8
    DB 10110111B                ; 9
    DB 01110111B                ; A
    DB 11110100B                ; B
    DB 11010001B                ; C
    DB 11100110B                ; D
    DB 11110001B                ; E
    DB 01110001B                ; F
    DB 00000000B                ; Extinguishes
END

```

## CHAPTER 13 APPLICATIONS OF KEY INPUT

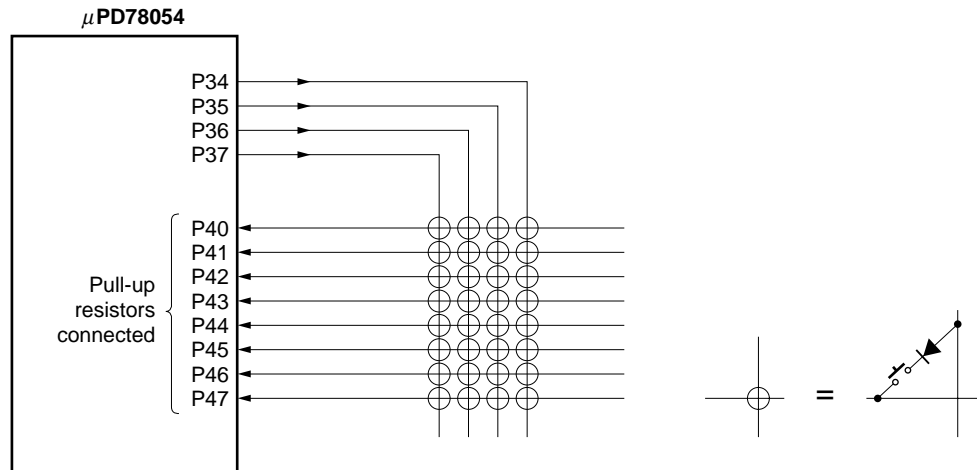
This chapter introduces an example of a program that inputs signals from a key matrix of  $4 \times 8$  keys. The key scan can be pressed successively, and two or more keys can be pressed simultaneously. In the circuit shown in this section, the high-order 4 bits of port 3 (P34 through P37) are used as key scan signals, and port 4<sup>Note</sup> is used as key return signals. As the pull-up resistor of port 4 for key return, the internal pull-up resistor set by software is used (refer to **Figure 13-1**).

Port 4 of the 78K/0 series has a function to detect the falling edges of the eight port pins in parallel. If port 4 is used for key return signals, therefore, the standby mode can be released through detection of a falling edge, i.e., by key input.

In this example, the  $\mu$ PD78054 subseries is used.

**Note** With the  $\mu$ PD78064, 78064Y, 780308, 780308Y, and 78064B subseries, port 11 is used instead of port 4.

**Figure 13-1. Key Matrix Circuit**



The input keys are stored to RAM on a one key-to-1 bit basis. The RAM bit corresponding to a pressed key is set and the bit corresponding to a released key is cleared. By testing the RAM data on a 1-bit-by-1-bit basis starting from the first bit, the key status can be checked. To absorb chattering, the key is assumed to be valid when four successive key codes coincide with a given code. For example, if a key code is sampled every 5 ms, chattering of 15 ms to 20 ms can be absorbed. If the key input is changed, a key change flag (KEYCHG) is set.

**(1) Description of package****<Public declaration symbol>**

KEYIN : Key input subroutine name  
 KEYDATA : Key data storage area  
 CHATCT : Chattering counter  
 KEYCHG : Key change test flag

**<Register used>**

AX, DE, HL

**<RAM used>**

| Name    | Usage                             | Attribute | Bytes |
|---------|-----------------------------------|-----------|-------|
| KEYDATA | Stores valid key data             | SADDR     | 4     |
| WORK    | Stores key data during chattering |           |       |
| CHATCT  | Chattering counter                |           | 1     |
| WORKCT  | Loop processing work counter      |           |       |

**<Flag used>**

| Name   | Usage                      |
|--------|----------------------------|
| CHGFG  | Set if key input changes   |
| KEYCHG | Set if valid key changes   |
| CHTEND | Confirms end of chattering |

**<Nesting>**

1 level 2 bytes

**<Hardware used>**

- P4
- P3 (P34-P37)

**<Initial setting>**

- PU04 = 1 ; Connects pull-up resistor to P4
- PM3 = #0000xxxxB ; Sets high-order 4 bits of P3 in output mode

**<Starting>**

- Call KEYIN at specific intervals.
- Before inputting the key data, test the key change flag. The key change flag is not cleared by the subroutine. Clear the flag after it has been tested.



## (2) Example of use

```

        EXTRN    KEYDATA,CHATCT,KEYIN
        EXTBIT   KEYCHG

VETM3   CSEG    AT 1EH
        DW      INTTM3                               ; Sets vector address of watch timer

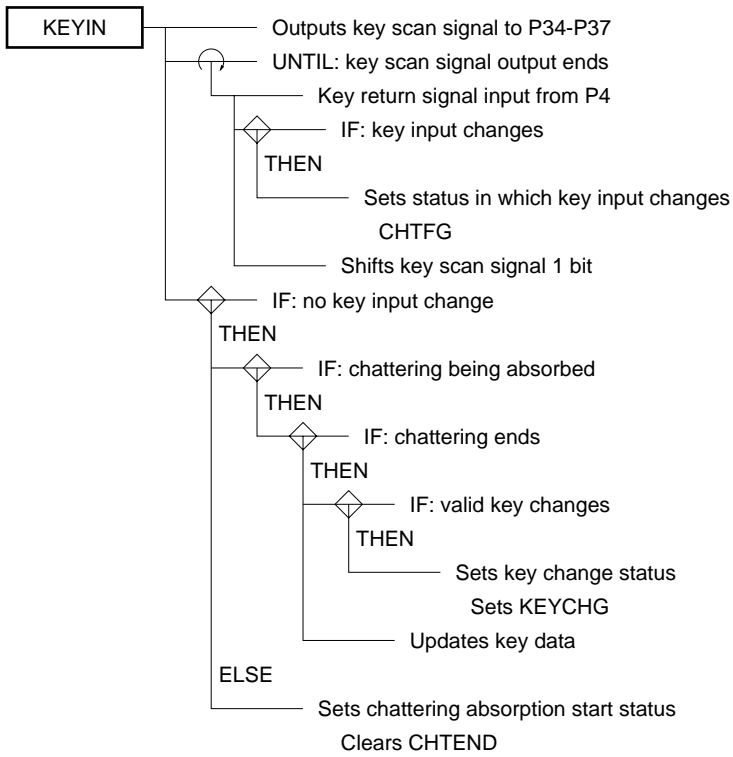
MAINDAT DSEG    SADDR
CT5MS:  DS      1
        .
        .
TMC2=#00100110B
CLR1    TMMK3
CT5MS=#3

PM3=#00000000B                               ; Sets P3 in output mode
SET1    PUO.4                                 ; Pulls P4 up
CHATCT=#3                                    ; Initial setting of chattering counter
        .
        .
if_bit(KEYCHG)                                ; Key changed?
        CLR1   KEYCHG
        ; Key input processing
endif
        .
        .
;*****
;      Watch timer interrupt processing
;      Interval time: 1.95 ms
;*****
INTTM3:                                     ; 1.95 ms interrupt
        .
        .
        DBNZ   CT5MS,$RTNTM3
        MOV    CT5MS,#3                       ; 1.95 ms × 3 elapses
        CALL  !ANKEYIN

RTNTM3:
        .
        .
        RETI

```

(3) SPD chart



## (4) Program list

```

PUBLIC KEYDATA,KEYCHG,KEYIN,CHATCT

KEY_DAT DSEG SADDR
KEYDATA:DS 4 ; Key data storage area
WORK: DS 4 ; Chattering key data
CHATCT: DS 1 ; Chattering counter
WORKCT: DS 1

KEY_FLG BSEG
CHGFG DBIT ; Key change status
KEYCHG DBIT ; Key changed
CHTEND DBIT ; Chattering absorption end status

KEY_SEG CSEG
;*****
* Matrix key input
;*****
KEYIN:
CLR1 CHGFG
P3&=#00001111B
P3|=#00010000B
HL=#WORK ; Sets address of key work area
repeat
A=P4
A^=#11111111B ; Data inverted
if(A!=[HL]) ; Key changed?
SET1 CHGFG
[HL]=A
endif
HL++
A=P3 ; Shifts key scan 1 bit
A&=#11110000B
X=A
A=P3
A+=X
P3=A
until_bit(CY)

if_bit(!CHGFG) ; Key changed
if_bit(!CHTEND) ; Chattering absorbed
CHATCT-- ; Chattering ends
if(CHATCT==#0)
SET1 CHTEND
DE=#WORK
HL=#KEYDATA
for(WORKCT=#0;WORKCT<#4;WORKCT++)
if([DE]!=[HL]) (A) ; Key changed
SET1 KEYCHG
endif
A<->[HL] ; Transfers WORK to KEYDATA
HL++
DE++
next
endif
endif
else
CHATCT=#3
CLR1 CHTEND
endif
RET

```

[MEMO]

## APPENDIX A DESCRIPTION OF SPD CHART

SPD stands for Structured Programming Diagrams.

Structuring means structuring the logical processing of a program, and designing and formulating the logic by using the basic structure of the logic elements.

All programs can be created by only combining the basic structure of logic elements, (sequentially, selectively, or repeatedly). (This is called a structured theorem). Through structuring, the flow of a program is clarified, and the reliability is improved. Although various methods are available for expressing the structuring of a program, NEC employs a diagram technique called SPD.

The following table describes the SPD symbols used for the SPD technique and compares them with flowchart symbols.

**Table A-1. Comparison between SPD Symbols and Flowchart Symbol (1/2)**

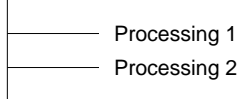
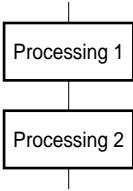
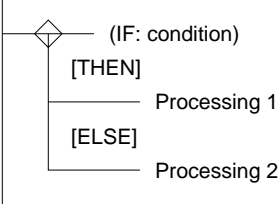
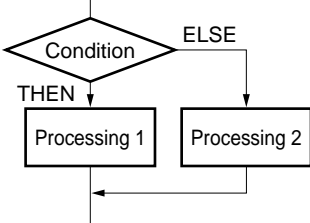
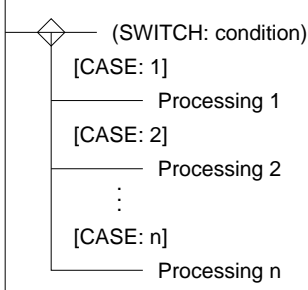
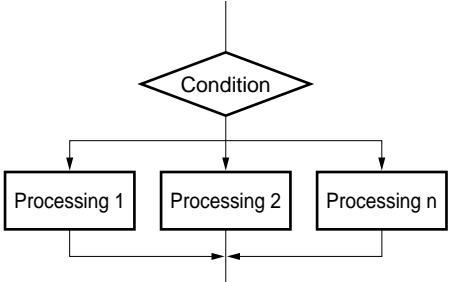
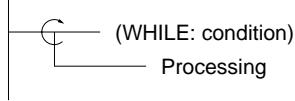
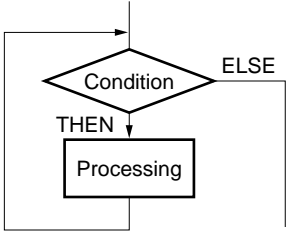
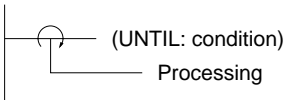
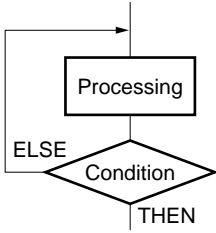
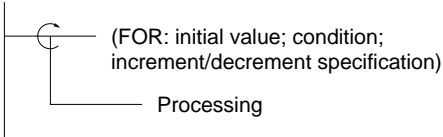
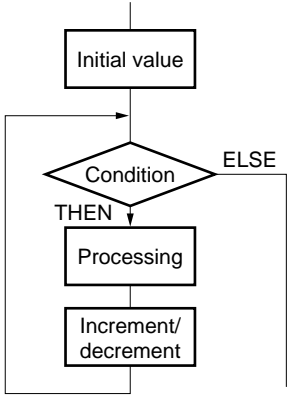
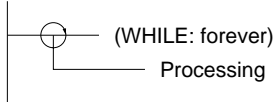
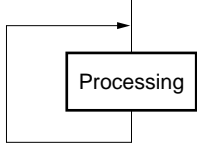
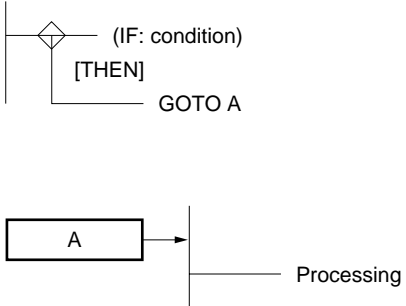
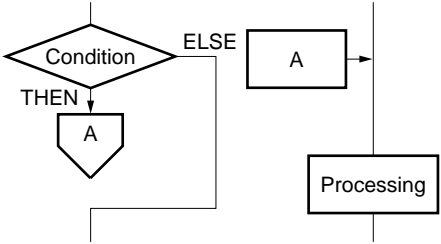
| Processing Name             | SPD Symbol  | Flowchart Symbol  |
|-----------------------------|---|---|
| Sequential processing       |    |    |
| Conditional branch (IF)     |  |  |
| Conditional branch (SWITCH) |  |   |

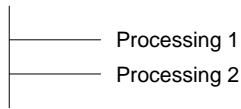
Table A-1. Comparison between SPD Symbols and Flowchart Symbol (2/2)

| Processing Name          | SPD Symbol  | Flowchart Symbol  |
|--------------------------|---|---|
| Conditional loop (WHILE) |    |    |
| Conditional loop (UNTIL) |    |    |
| Conditional loop (FOR)   |   |   |
| Infinite loop            |  |  |
| Connector                |  |   |

**1. Sequential processing**

Sequential processing executes processing from top to bottom in the sequence in which processing appears.

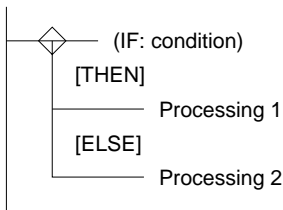
• SPD chart



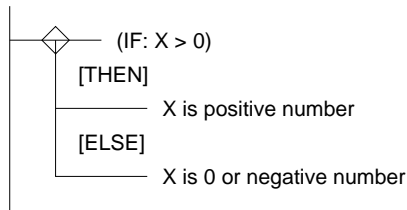
**2. Conditional branch: 2 branch (IF)**

Processing contents are selected according to the condition specified by IF is true or false (THEN/ELSE).

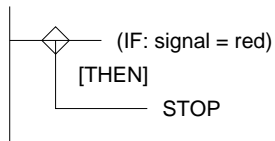
• SPD chart



**Example 1.** Identification of positive or negative of X



**2.** STOP if signal is red

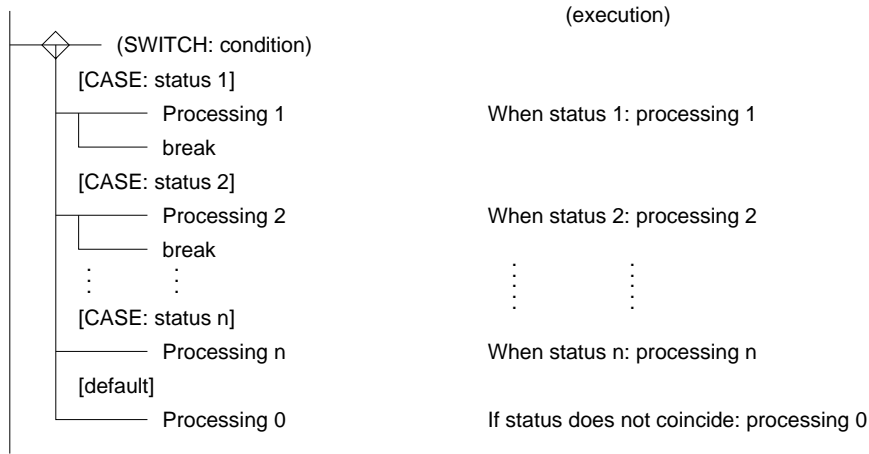


### 3. Conditional branch: multiple branch (SWITCH)

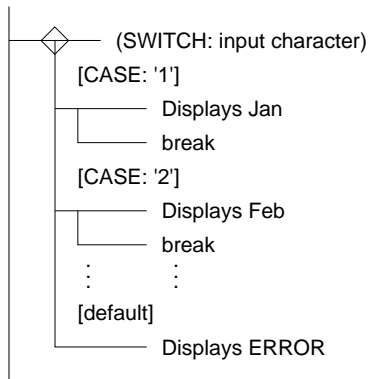
The condition specified by SWITCH is compared with the status indicated by CASE to select the processing. The processing of the SWITCH statement may be executed only when the given values coincide, or continued downward starting from when the given values coincide (if the processing is not continued downward, 'break' is described). If there is no coincide status, 'default' processing is executed (description of 'default' is arbitrary).

#### (1) Execution only on coincidence

- SPD chart



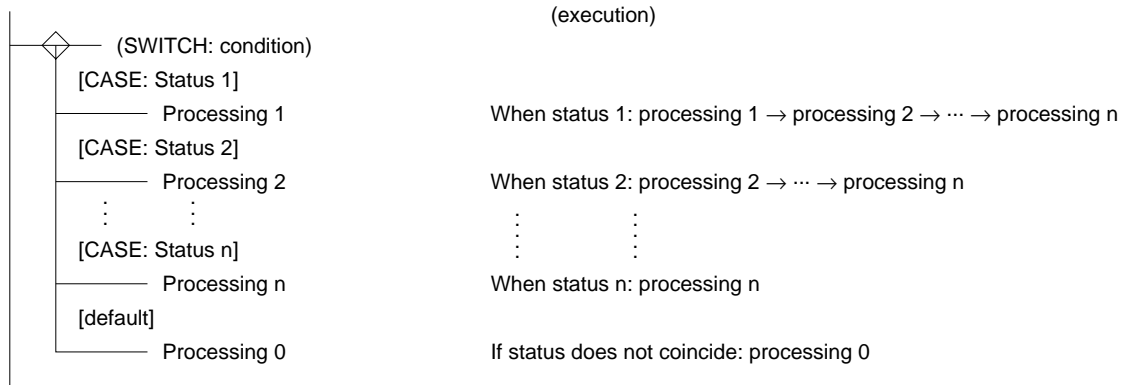
**Example** Displays name of month by input characters



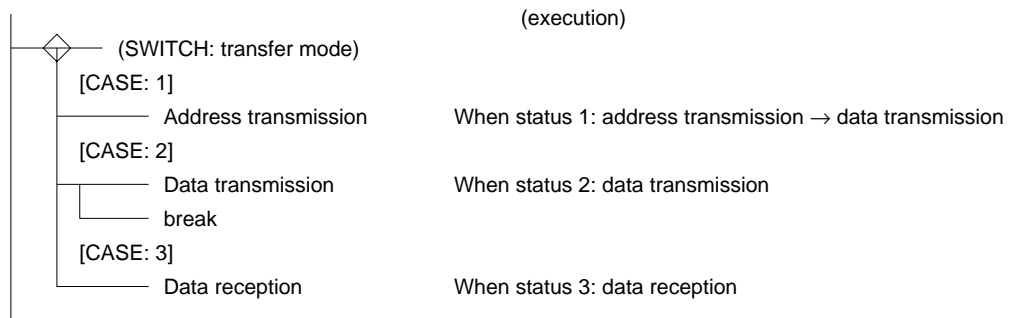


(2) If processing continues from coincidence status

• SPD chart



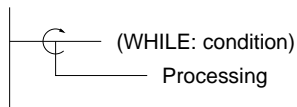
**Example** Transmission/reception of serial interface



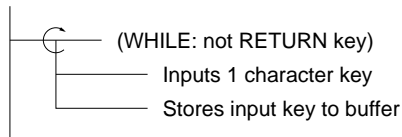
**4. Conditional Loop (WHILE)**

The condition indicated by WHILE is judged. If the condition is satisfied, processing is repeatedly executed (if the condition is not satisfied from the start, the processing is not executed).

• SPD chart



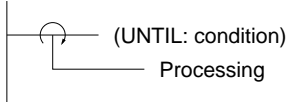
**Example** Buffers key until RETURN key is input



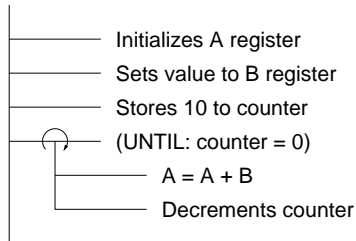
### 5. Conditional Loop (UNTIL)

The condition indicated by UNTIL is judged after processing has been executed, and the processing is repeatedly executed until a given condition is satisfied (even if the condition is not satisfied from the start, the processing is executed once).

- SPD chart



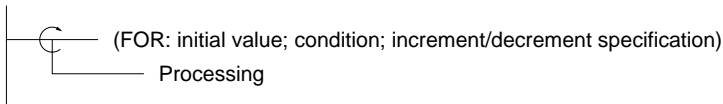
**Example** Multiplies value of B register by 10 and stores result to A register



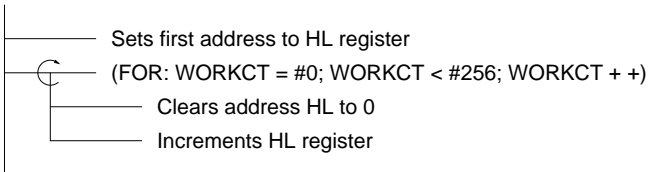
### 6. Conditional Loop (FOR)

While the condition of the parameter indicated by FOR is satisfied, processing is repeatedly executed.

- SPD chart



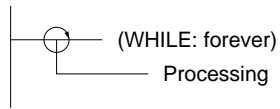
**Example** Clears 256 bytes to 0 starting from address HL



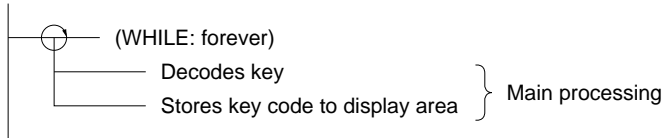
## 7. Infinite Loop

If 'forever' is set as the condition of WHILE, processing is infinitely executed.

- SPD chart



**Example** To execute main processing repeatedly

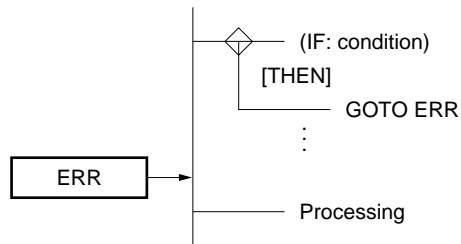


## 8. Connector (GOTO)

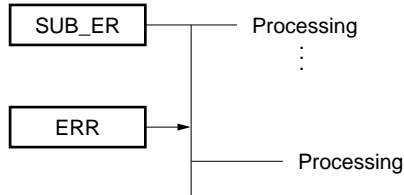
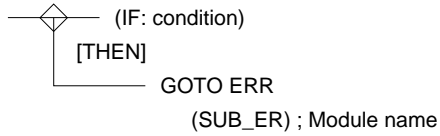
Unconditionally branches to a specified address.

- SPD chart

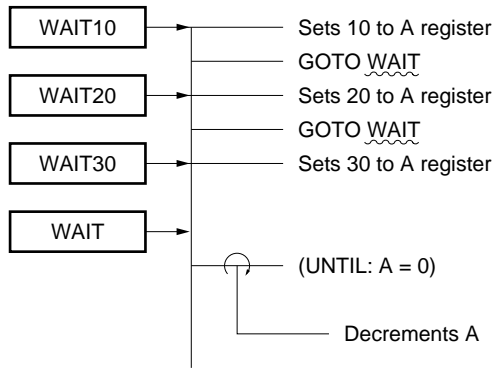
(1) To branch to same module



(2) To branch to different module



**Example** To select a parameter at the start address of a subroutine and set wait state



**9. Connector (continuation)**

Used when the SPD of one module requires two or more pages to indicate the flow of processing.

• SPD chart





## APPENDIX B REVISION HISTORY

The revision history of this document is as follows. “Chapter” indicates the chapter number in the preceding edition. (1/2)

| Edition     | Major Revision from Preceding Edition  | Chapter   |
|-------------|--|---|
| 2nd edition | Addition of following products as target products:<br>$\mu$ PD780018, 780018Y, 780058, 780058Y, 780308, 780308Y,<br>78058F, 78058FY, 78064B, 78075B, 78075BY, 78098B<br>subseries, $\mu$ PD78070A, 78070AY<br>$\mu$ PD78052(A), 78053(A), 78054(A)<br>$\mu$ PD78062(A), 78063(A), 78064(A)<br>$\mu$ PD78081(A), 78082(A), 78P083(A), 78081(A2)<br>$\mu$ PD78058F(A), 78058FY(A)<br>$\mu$ PD78064B(A) | Throughout  |
|             | Deletion of following products as target products:<br>$\mu$ PD78P054Y, 78P064Y, 78074, 78075, 78074Y, 78075Y   |   |
|             | Addition of Note 2 and Caution 2 to Figure 4-5 Format of Watchdog Timer Mode Register  | CHAPTER 4 APPLICATION OF WATCHDOG TIMER             |
|             | Addition of Caution to Figure 5-8 Format of External Interrupt Mode Register 0   | CHAPTER 5 APPLICATION OF 16-BIT TIMER/EVENT COUNTER |
|             | Addition of Table 8-2 Items Supported by Each Subseries  | CHAPTER 8 APPLICATION OF SERIAL INTERFACE           |
|             | Addition of Table 8-3 Registers of Serial Interface  |   |
|             | Addition of note on using wake-up function and note on changing operation mode to Figures 8-7 and 8-8 Format of Serial Operating Mode Register 0   |   |
|             | Addition of Caution to Figures 8-16 and 8-17 Format of Automatic Data Transmission/Reception Interval Specification Register   |   |
|             | Addition of Figures 8-23 and 8-24 Format of Serial Interface Pin Select Register   |   |
|             | $\mu$ PD6252 as maintenance product in 8.1 Interface with EEPROM™ ( $\mu$ PD6252)  |   |
|             | Addition of (5) Limitations when using I <sup>2</sup> C bus mode to 8.1.2 Communication in I <sup>2</sup> C bus mode   |   |
|             | Addition of (f) Limitations when using UART mode to 8.5 Interface in Asynchronous Serial Interface (UART) Mode   |   |

**APPENDIX B REVISION HISTORY**

(2/2)

| Edition     | Major Revision from Preceding Edition   | Chapter   |
|-------------|---|---|
| 2nd edition | Description of following register formats and tables for each subseries:<br>Figures 8-14 and 8-15 Format of Automatic Data Transfer/ Reception Control Register<br>Tables 8-4, 8-5, and 8-6 Setting of Operating Modes of Serial Interface Channel 2<br>Figures 12-1 and 12-2 Format of LCD Display Mode Register | CHAPTER 8 APPLICATION OF SERIAL INTERFACE       |
|             | Addition of Figure 11-3 Format of Port Mode Register 12   | CHAPTER 11 APPLICATION OF REAL-TIME OUTPUT PORT |
|             | Description of following register formats for each subseries:<br>Figures 12-1 and 12-2 Format of LCD Display Mode Register  | CHAPTER 12 APPLICATION OF LCD CONTROLLER/DRIVER |

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