

# MOS INTEGRATED CIRCUIT

# $\mu$ PD70208H, 70216H

## V40HL™, V50HL™

## 16/8, 16-BIT MICROPROCESSOR

### DESCRIPTION

The  $\mu$ PD70208H (V40HL) is a high-speed, low-power 16-/8-bit microprocessor based on the  $\mu$ PD70208 (V40™) with 16-bit architecture, 8-bit data bus, and general-purpose peripheral functions.

The  $\mu$ PD70216H (V50HL) is a high-speed, low-power 16-bit microprocessor based on the  $\mu$ PD70216 (V50™) with 16-bit architecture, 16-bit data bus, and general-purpose peripheral functions.

The V40HL and V50HL offer 20 MHz operation, and in addition to the conventional standby functions, also allows the clock to be stopped by the use of fully static internal circuitry, thus achieving greatly reduced power consumption. It is also capable of 3 V operation in addition to the previous 5 V operation, making it ideally suited to battery driven systems.

**Details are given in the following manuals. Be sure to read when carrying out design work.**

- **V40HL, V50HL User's Manual – Hardware (U11610E)**
- **16-bit V series™ User's Manual – Instruction (U11301J: Japanese version)**

### FEATURES

- High-speed, low-power version of V40 and V50
- High-performance CPU (V20™/V30™ software compatible)
  - Minimum instruction execution time: 100 ns (20 MHz, 5 V)  
200 ns (10 MHz, 3 V)
  - Memory addressing space: 1M bytes
  - High-speed multiply/divide instructions: 0.95 to 2.8  $\mu$ s (20 MHz, 5 V)  
1.9 to 5.6  $\mu$ s (10 MHz, 3 V)
  - Maskable (ICU) & non-maskable (NMI) interrupt inputs
  - $\mu$ PD8080AF emulation function
  - Standby functions, clock stoppage capability
- Standard peripheral LSI functions on chip
  - Clock generator (CG)
  - Programmable wait control unit (WCU)
  - Refresh control unit (REFU)
  - Timer/counter unit (TCU) ...  $\mu$ PD71054 subset
  - Serial control unit (SCU) ...  $\mu$ PD71051 subset
  - Interrupt control unit (ICU) ...  $\mu$ PD71059 subset
  - DMA control unit (DMAU) ...  $\mu$ PD71071/71037 subset (functions of either selectable)
- Operating frequency: 10/12.5/16/20 MHz (at 5 V, with 20/25/32/40 MHz supplied externally)  
5/6.25/8/10 MHz (at 3 V, with 10/12.5/16/20 MHz supplied externally)

The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.

Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

## ORDERING INFORMATION

## (1) V40HL

| Part Number              | Package                                                                   | Max. Operating Frequency (MHz) |
|--------------------------|---------------------------------------------------------------------------|--------------------------------|
| $\mu$ PD70208HGF-10-3B9  | 80-pin plastic QFP (14 × 20 mm)<br>(Resin thickness 2.7 mm)               | 10                             |
| $\mu$ PD70208HGF-12-3B9  | 80-pin plastic QFP (14 × 20 mm)<br>(Resin thickness 2.7 mm)               | 12.5                           |
| $\mu$ PD70208HGF-16-3B9  | 80-pin plastic QFP (14 × 20 mm)<br>(Resin thickness 2.7 mm)               | 16                             |
| $\mu$ PD70208HGF-20-3B9  | 80-pin plastic QFP (14 × 20 mm)<br>(Resin thickness 2.7 mm)               | 20                             |
| $\mu$ PD70208H GK-10-9EU | 80-pin plastic TQFP (Fine pitch) (12 × 12 mm)<br>(Resin thickness 1.0 mm) | 10                             |
| $\mu$ PD70208H GK-12-9EU | 80-pin plastic TQFP (Fine pitch) (12 × 12 mm)<br>(Resin thickness 1.0 mm) | 12.5                           |
| $\mu$ PD70208H GK-16-9EU | 80-pin plastic TQFP (Fine pitch) (12 × 12 mm)<br>(Resin thickness 1.0 mm) | 16                             |
| $\mu$ PD70208H GK-20-9EU | 80-pin plastic TQFP (Fine pitch) (12 × 12 mm)<br>(Resin thickness 1.0 mm) | 20                             |
| $\mu$ PD70208HLP-10      | 68-pin plastic QFJ (950 × 950 mil)                                        | 10                             |
| $\mu$ PD70208HLP-12      | 68-pin plastic QFJ (950 × 950 mil)                                        | 12.5                           |
| $\mu$ PD70208HLP-16      | 68-pin plastic QFJ (950 × 950 mil)                                        | 16                             |
| $\mu$ PD70208HLP-20      | 68-pin plastic QFJ (950 × 950 mil)                                        | 20                             |

## (2) V50HL

| Part Number              | Package                                                                   | Max. Operating Frequency (MHz) |
|--------------------------|---------------------------------------------------------------------------|--------------------------------|
| $\mu$ PD70216HGF-10-3B9  | 80-pin plastic QFP (14 × 20 mm)<br>(Resin thickness 2.7 mm)               | 10                             |
| $\mu$ PD70216HGF-12-3B9  | 80-pin plastic QFP (14 × 20 mm)<br>(Resin thickness 2.7 mm)               | 12.5                           |
| $\mu$ PD70216HGF-16-3B9  | 80-pin plastic QFP (14 × 20 mm)<br>(Resin thickness 2.7 mm)               | 16                             |
| $\mu$ PD70216HGF-20-3B9  | 80-pin plastic QFP (14 × 20 mm)<br>(Resin thickness 2.7 mm)               | 20                             |
| $\mu$ PD70216H GK-10-9EU | 80-pin plastic TQFP (Fine pitch) (12 × 12 mm)<br>(Resin thickness 1.0 mm) | 10                             |
| $\mu$ PD70216H GK-12-9EU | 80-pin plastic TQFP (Fine pitch) (12 × 12 mm)<br>(Resin thickness 1.0 mm) | 12.5                           |
| $\mu$ PD70216H GK-16-9EU | 80-pin plastic TQFP (Fine pitch) (12 × 12 mm)<br>(Resin thickness 1.0 mm) | 16                             |
| $\mu$ PD70216H GK-20-9EU | 80-pin plastic TQFP (Fine pitch) (12 × 12 mm)<br>(Resin thickness 1.0 mm) | 20                             |
| $\mu$ PD70216HLP-10      | 68-pin plastic QFJ (950 × 950 mil)                                        | 10                             |
| $\mu$ PD70216HLP-12      | 68-pin plastic QFJ (950 × 950 mil)                                        | 12.5                           |
| $\mu$ PD70216HLP-16      | 68-pin plastic QFJ (950 × 950 mil)                                        | 16                             |
| $\mu$ PD70216HLP-20      | 68-pin plastic QFJ (950 × 950 mil)                                        | 20                             |

# PIN CONFIGURATION (Top View)

## (1) V40HL

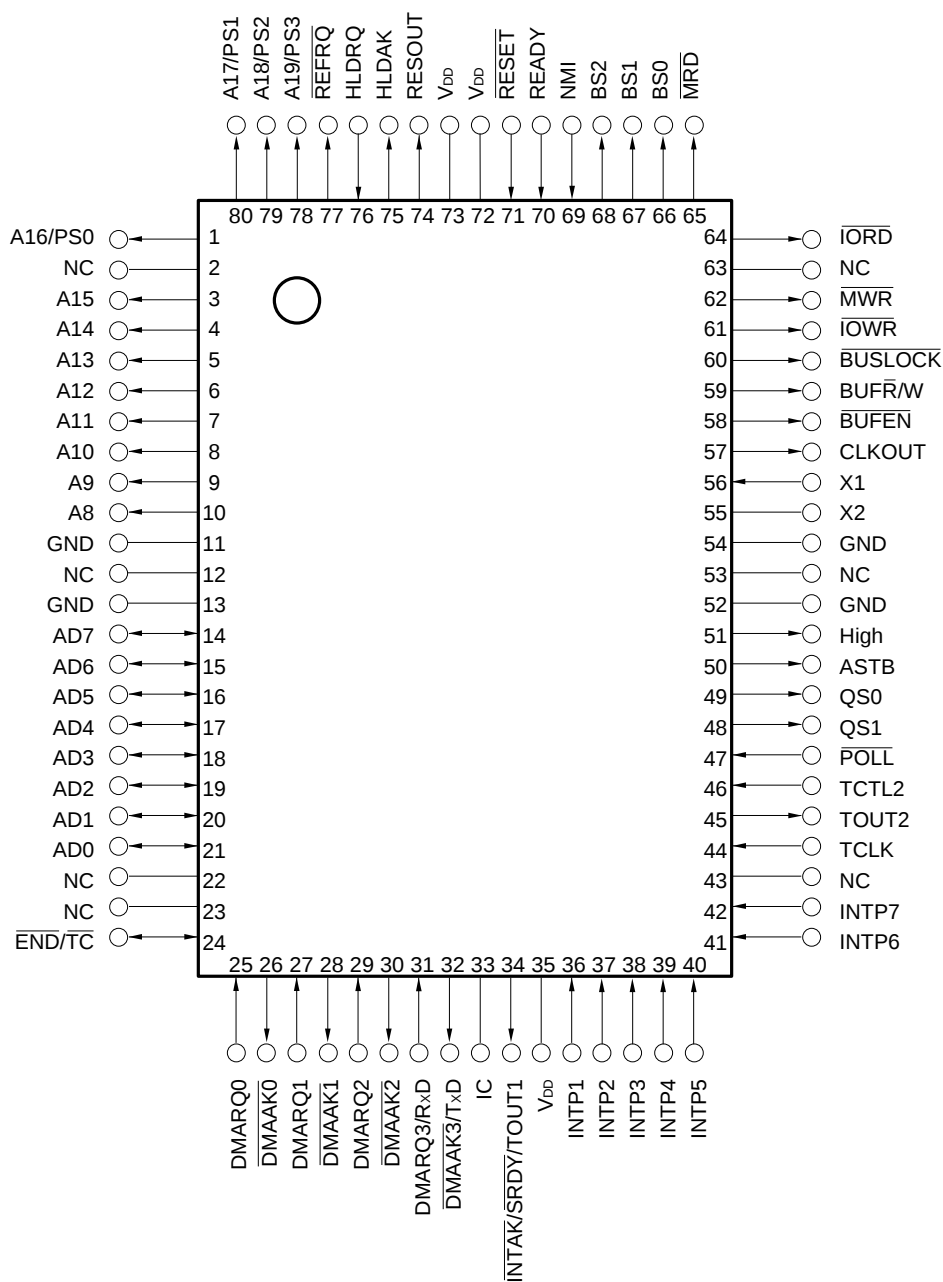
- 80-pin Plastic QFP (14 × 20 mm)

μPD70208HGF-10-3B9

μPD70208HGF-12-3B9

μPD70208HGF-16-3B9

μPD70208HGF-20-3B9



Caution Leave IC pin open.

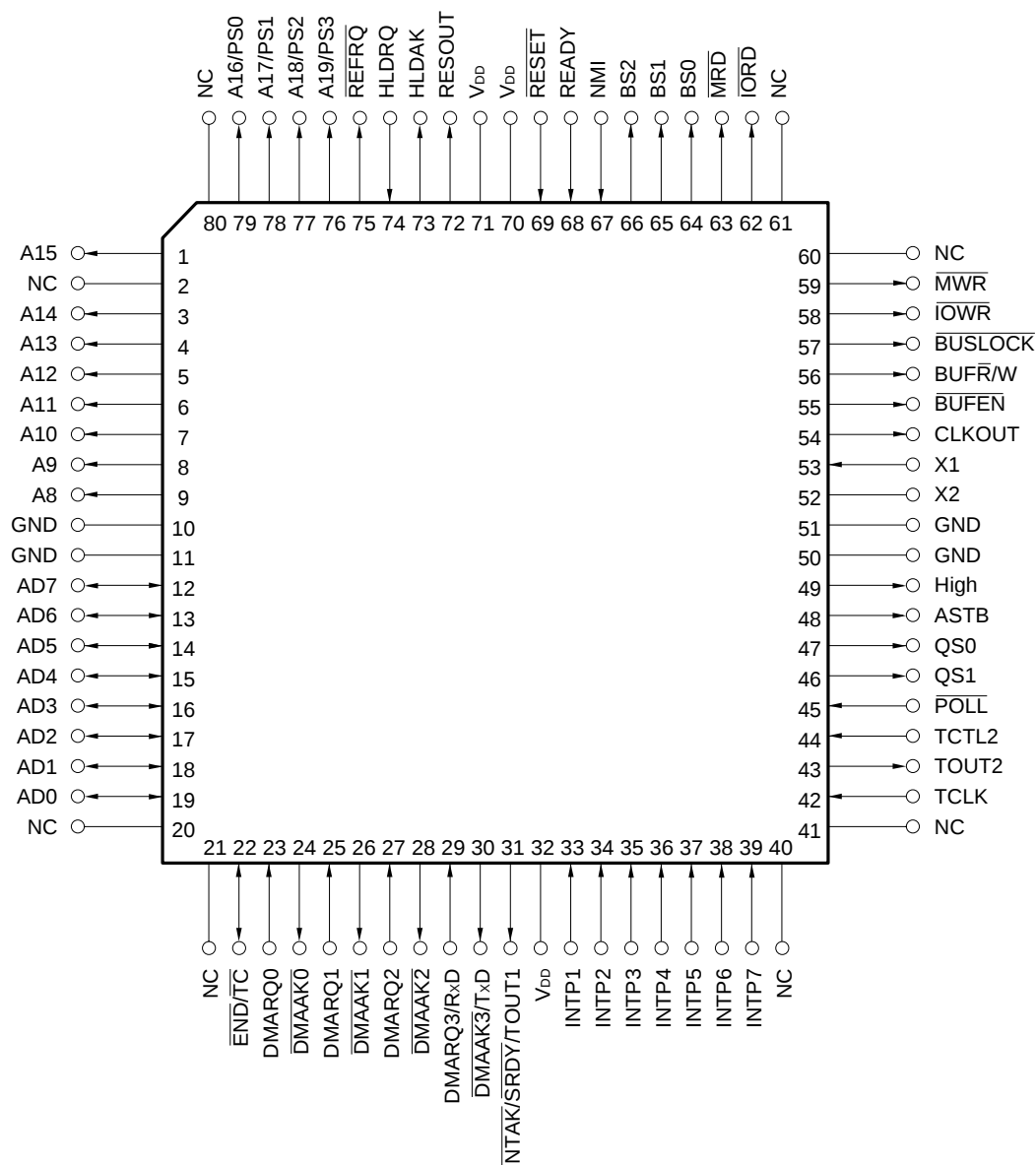
- 80-pin Plastic TQFP (Fine pitch) (12 × 12 mm)

μPD70208HGK-10-9EU

μPD70208HGK-12-9EU

μPD70208HGK-16-9EU

μPD70208HGK-20-9EU



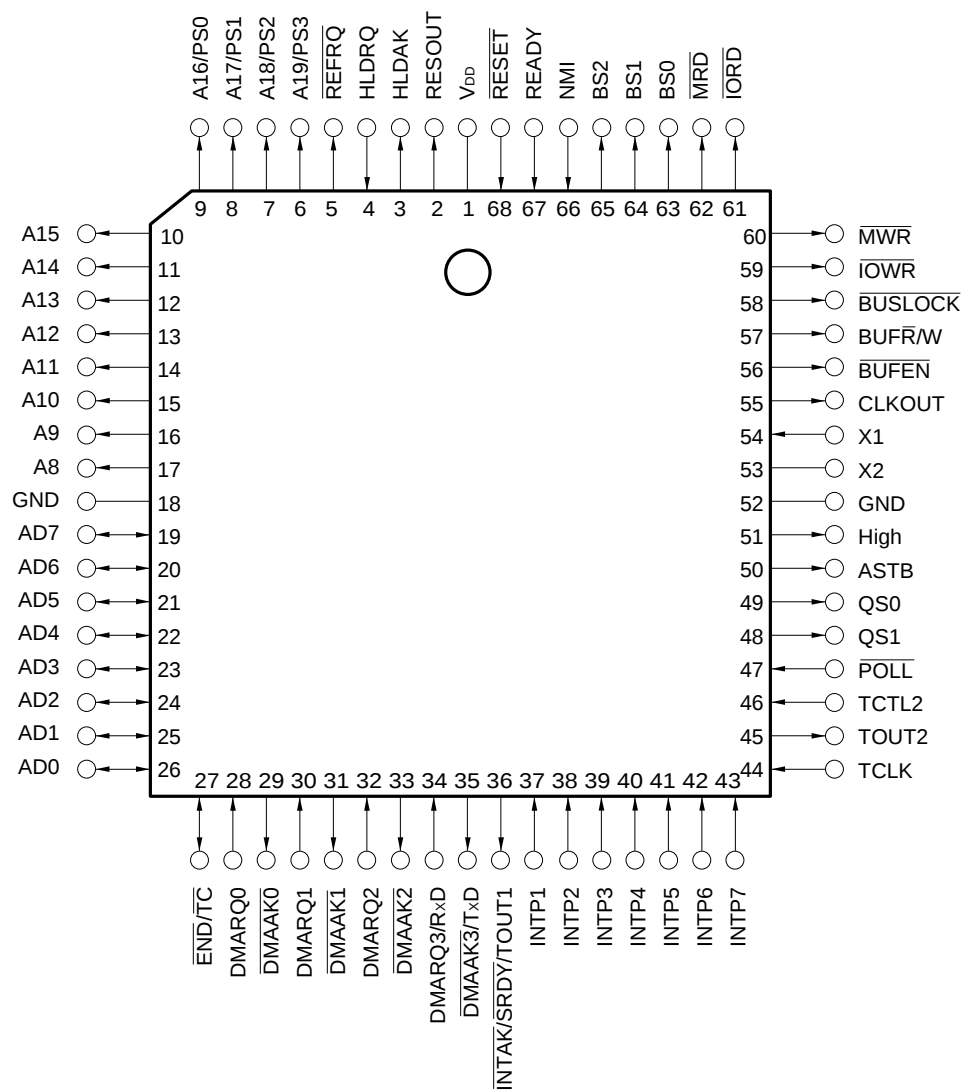
- 68-pin Plastic QFJ (950 × 950 mil)

μPD70208HLP-10

μPD70208HLP-12

μPD70208HLP-16

μPD70208HLP-20



(2) V50HL

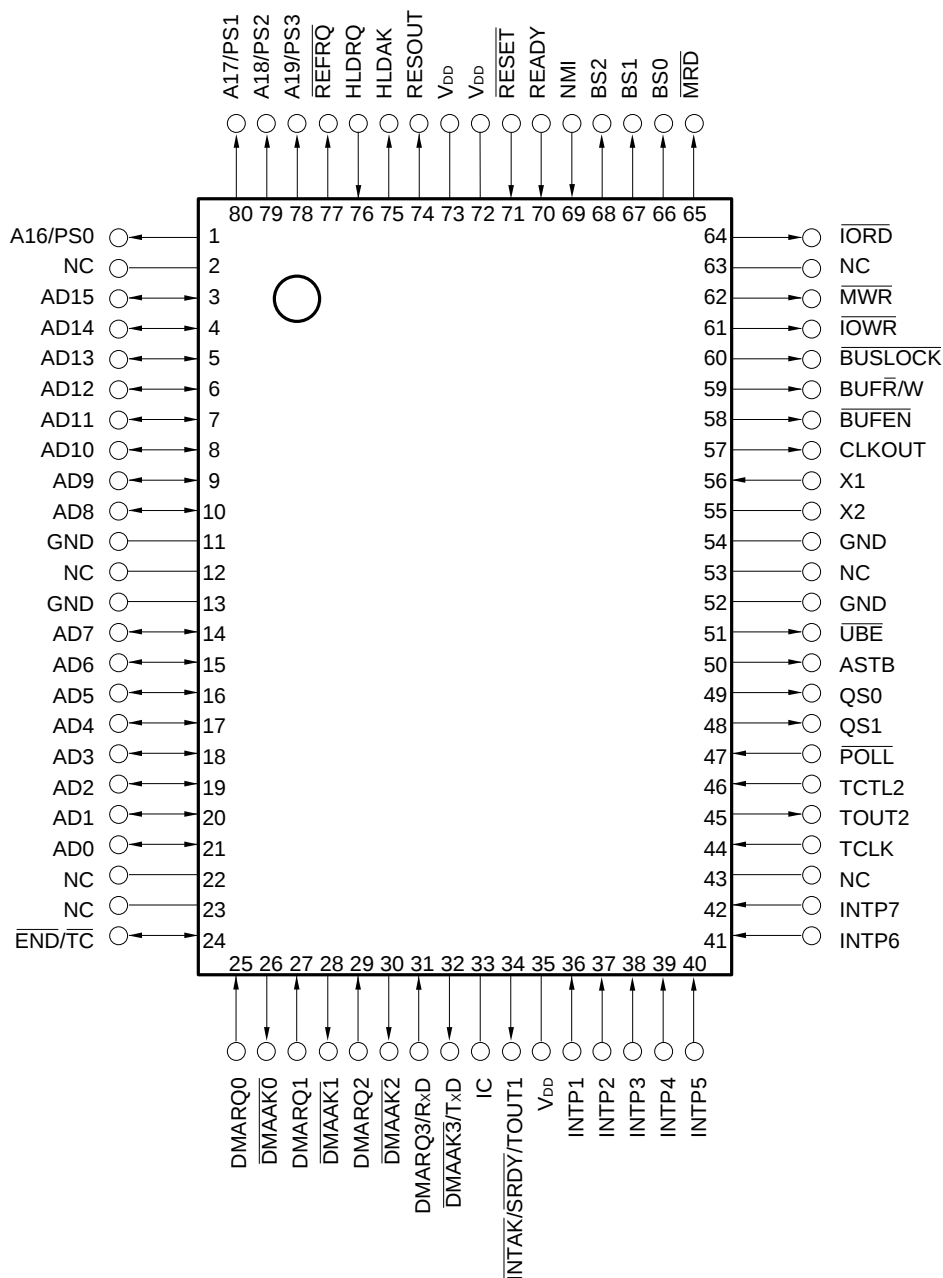
- 80-pin Plastic QFP (14 × 20 mm)

μPD70216HGF-10-3B9

μPD70216HGF-12-3B9

μPD70216HGF-16-3B9

μPD70216HGF-20-3B9



Caution Leave IC pin open.

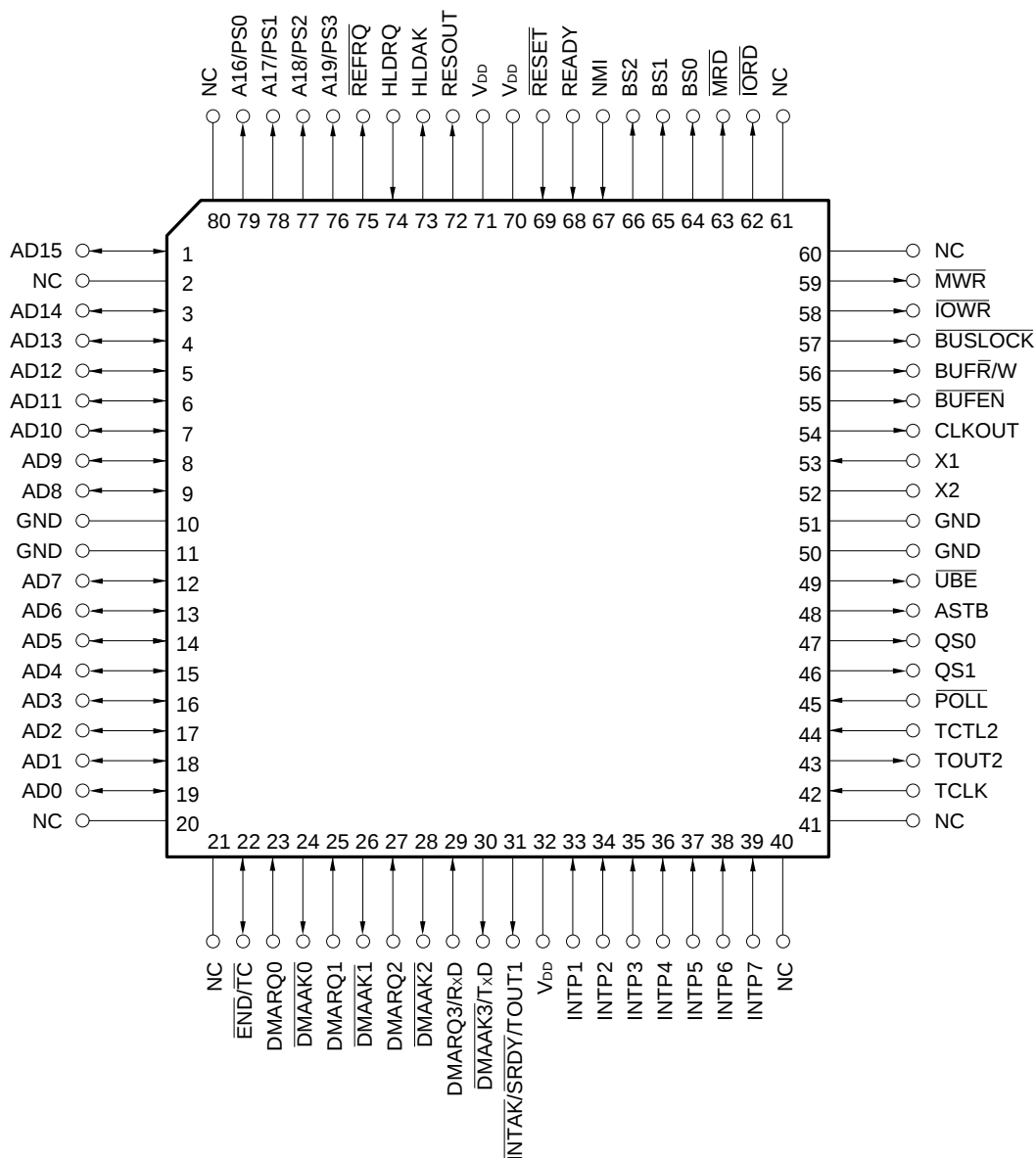
- 80-pin Plastic TQFP (Fine pitch) (12 × 12 mm)

μPD70216HGK-10-9EU

μPD70216HGK-12-9EU

μPD70216HGK-16-9EU

μPD70216HGK-20-9EU



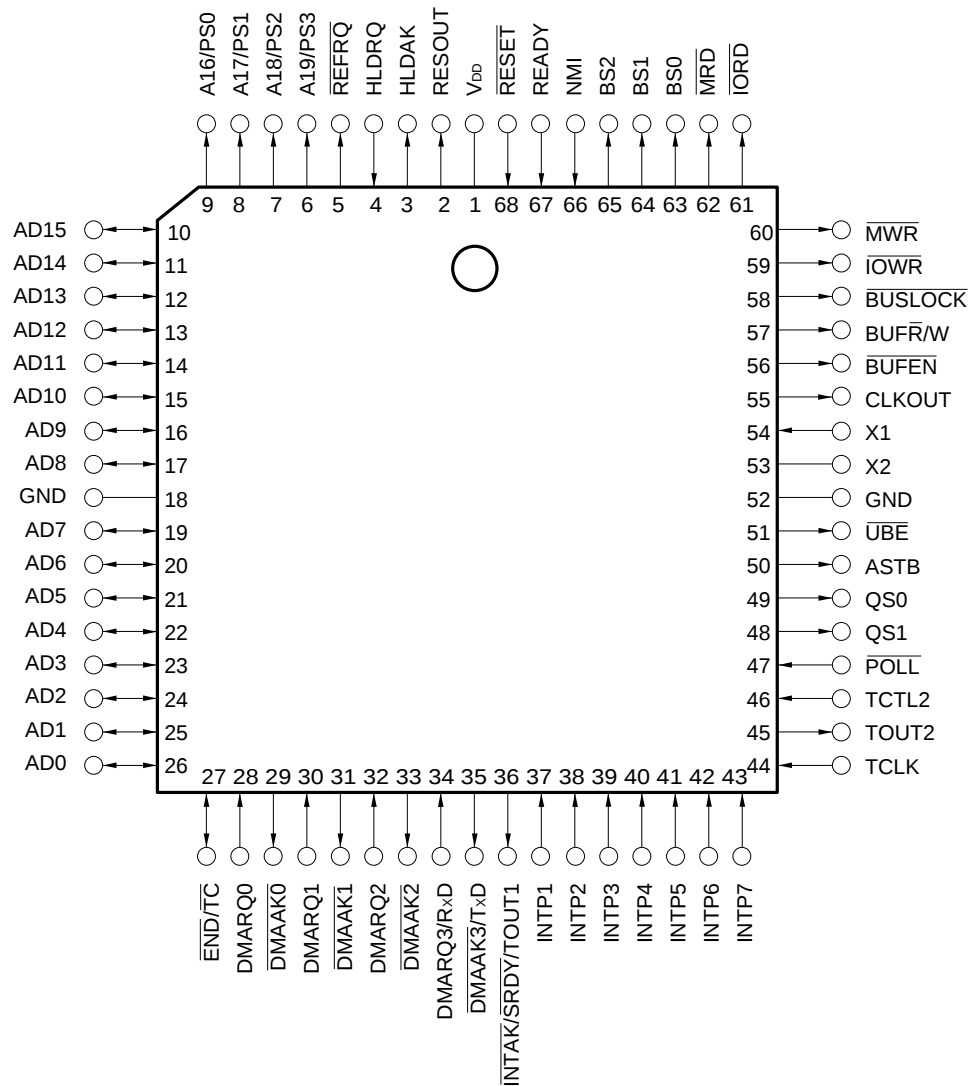
- 68-pin Plastic QFJ (950 × 950 mil)

μPD70216HLP-10

μPD70216HLP-12

μPD70216HLP-16

μPD70216HLP-20

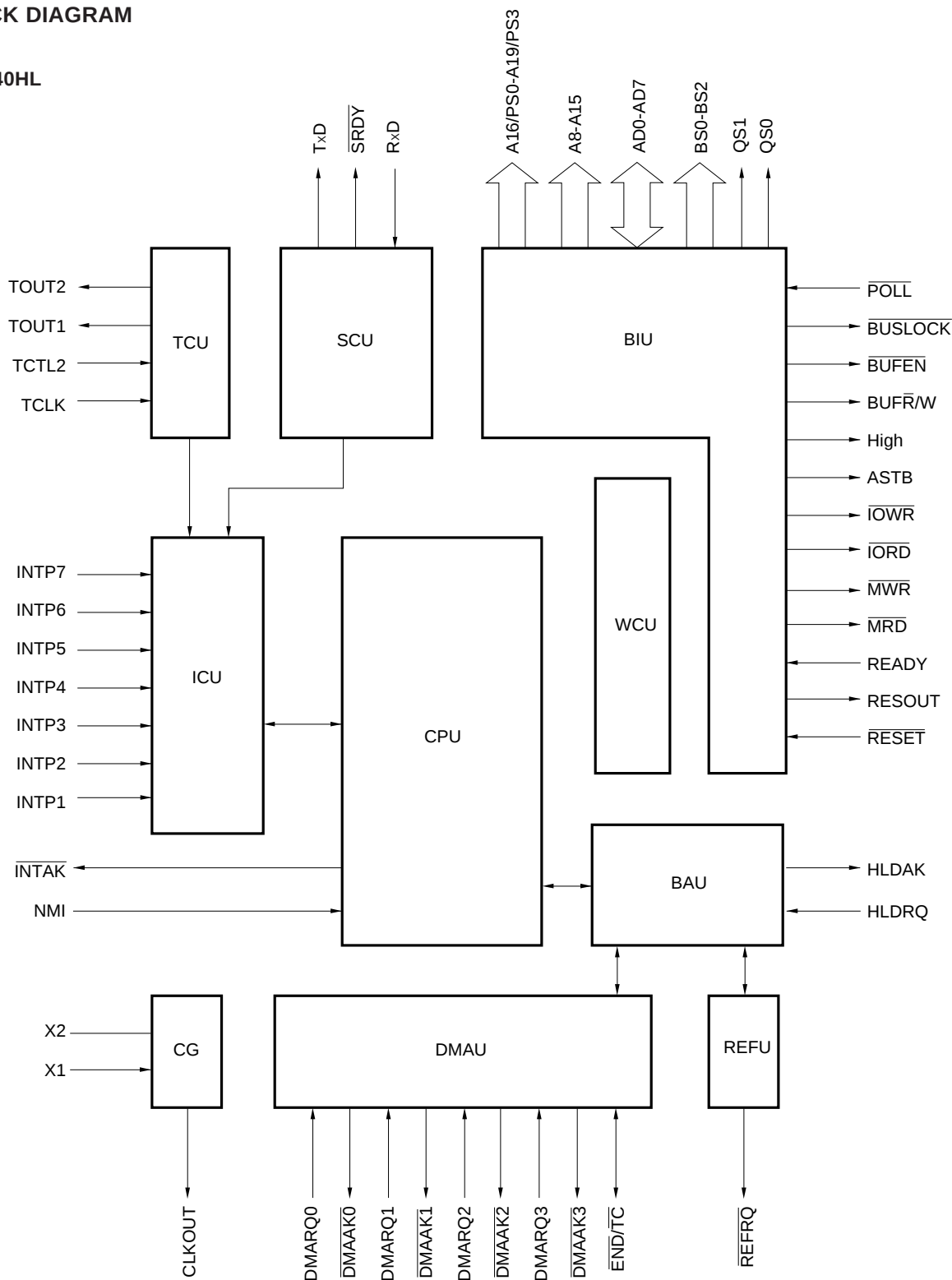


## PIN NAMES

|                     |                                                     |
|---------------------|-----------------------------------------------------|
| A8-A15              | : Address Bus                                       |
| A16/PS0-A19/PS3     | : Address/Processor Status                          |
| AD0-AD15            | : Address Bus/Data Bus                              |
| ASTB                | : Address Strobe                                    |
| BS0-BS2             | : Bus Status                                        |
| BUFEN               | : Buffer Enable                                     |
| BUFR $\overline{W}$ | : Buffer Read/Write                                 |
| BUSLOCK             | : Bus Lock                                          |
| CLKOUT              | : Clock Output                                      |
| DMAAK0-DMAAK2       | : DMA Acknowledge                                   |
| DMAAK3/TxD          | : DMA Acknowledge/Transmit Data                     |
| DMARQ0-DMARQ2       | : DMA Request                                       |
| DMARQ3/RxD          | : DMA Request/Receive Data                          |
| END/TC              | : End/Terminal Count                                |
| GND                 | : Ground                                            |
| High                | : High Level Output                                 |
| HLDK                | : Hold Acknowledge                                  |
| HLDRQ               | : Hold Request                                      |
| IC                  | : Internally Connected                              |
| INTAK/SRDY/TOUT1    | : Interrupt Acknowledge/Serial Ready/Timer Output 1 |
| INTP1-INTP7         | : Interrupt Request from Peripherals                |
| IORD                | : I/O Read                                          |
| IOWR                | : I/O Write                                         |
| MRD                 | : Memory Read                                       |
| MWR                 | : Memory Write                                      |
| NC                  | : No Connection                                     |
| NMI                 | : Non-Maskable Interrupt Request                    |
| POLL                | : Poll                                              |
| QS0, QS1            | : Queue Status                                      |
| READY               | : Ready                                             |
| REFRQ               | : Refresh Request                                   |
| RESET               | : Reset                                             |
| RESOUT              | : Reset Output                                      |
| TCLK                | : Timer Clock                                       |
| TCTL2               | : Timer Control 2                                   |
| TOUT2               | : Timer Output 2                                    |
| UBE                 | : Upper Byte Enable                                 |
| V <sub>DD</sub>     | : Power Supply                                      |
| X1, X2              | : Crystal                                           |

# BLOCK DIAGRAM

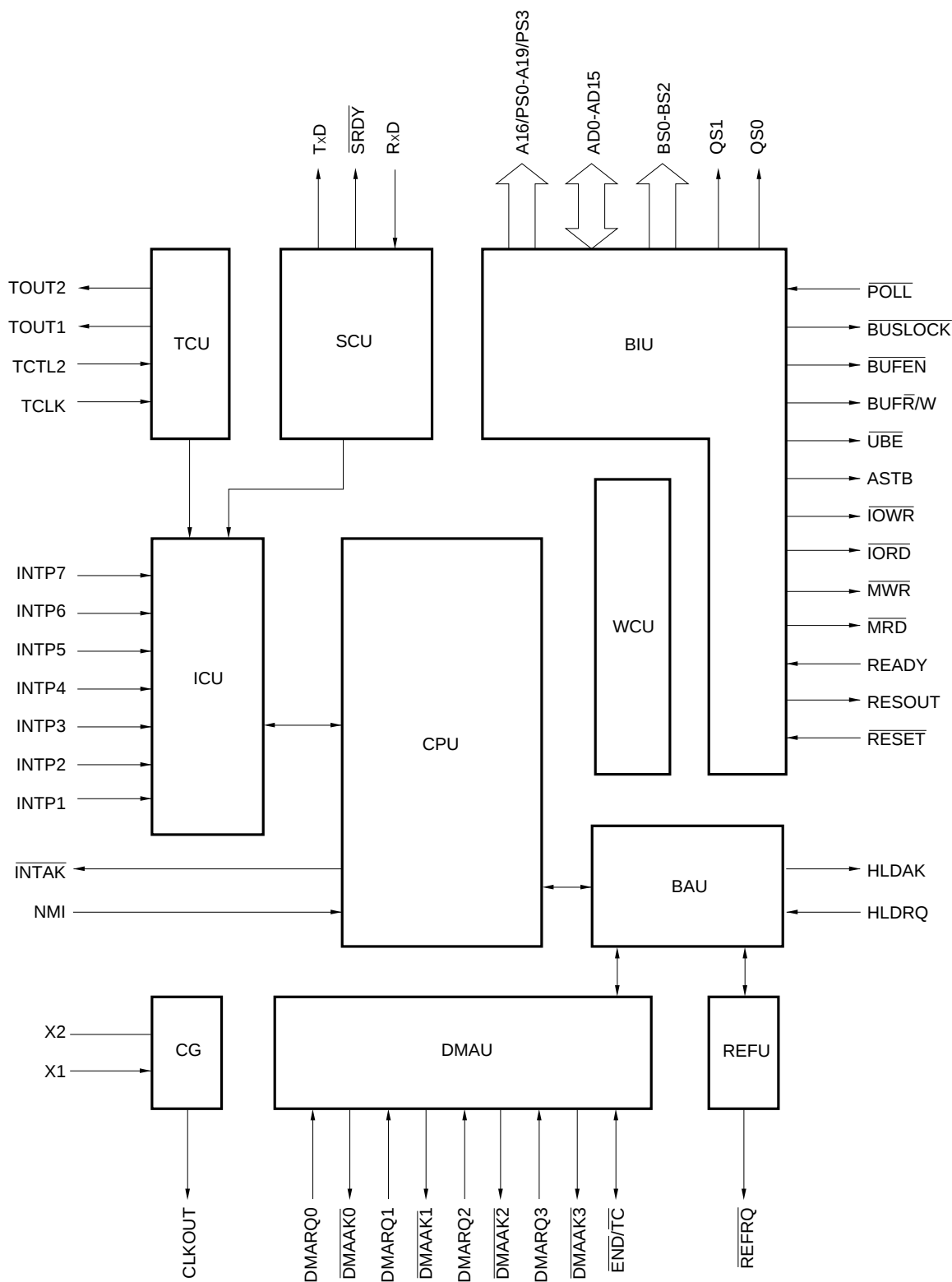
## (1) V40HL



CPU : Central Processing Unit  
CG : Clock Generator  
BIU : Bus Interface Unit  
BAU : Bus Arbitration Unit  
WCU : Wait Control Unit

REFU : Refresh Control Unit  
TCU : Timer/Count Unit  
SCU : Serial Control Unit  
ICU : Interrupt Control Unit  
DMAU : DMA Control Unit

(2) V50HL



## DIFFERENCES FROM V40 AND V50

| Item                             |                       | V40HL, V50HL                                                     | V40, V50                                                                                  |
|----------------------------------|-----------------------|------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| Operating supply voltage         |                       | 3 V, 5 V                                                         | 5 V                                                                                       |
| Operating frequency              | V <sub>DD</sub> = 5 V | MAX. : 10, 12.5, 16, 20 MHz<br>MIN. : DC                         | MAX. : 8, 10 MHz<br>MIN. : 2 MHz                                                          |
|                                  | V <sub>DD</sub> = 3 V | MAX. : 5, 6.25, 8, 10 MHz<br>MIN. : DC                           | No operation                                                                              |
| Clock generator (CG)             |                       | Variable scaling factor                                          | Fixed scaling factor                                                                      |
|                                  |                       | Variable instruction cycle time                                  | Fixed instruction cycle time                                                              |
|                                  |                       | Maximum input frequency: 40 MHz                                  | Maximum input frequency: 20 MHz                                                           |
| Internal I/O relocation function |                       | Switchable 8-bit boundary or 16-bit boundary relocation function | V40: Relocation possible on 8-bit boundary<br>V50: Relocation possible on 16-bit boundary |
| Wait control unit (WCU)          |                       | Memory space: 5 divisions <sup>Note 1</sup>                      | Memory space: 3 divisions                                                                 |
|                                  |                       | I/O space: 3 divisions <sup>Note 2</sup>                         | I/O space: Not divided                                                                    |
| Refresh control unit (REFU)      |                       | Refresh address: 16 bits                                         | Refresh address: 9 bits                                                                   |
|                                  |                       | $\overline{\text{REFRQ}}$ extended timing supported              | No $\overline{\text{REFRQ}}$ extended timing                                              |
| Serial control unit (SCU)        |                       | Dedicated baud rate generator incorporated                       | No dedicated baud rate generator incorporated                                             |
| DMA control unit (DMAU)          |                       | $\mu$ PD71071/71037 subset (either function selectable)          | $\mu$ PD71071 subset                                                                      |
| Standby functions                |                       | HALT mode, STOP mode                                             | HALT mode only                                                                            |

- Notes**
1. Divided into 3 when a reset is performed.
  2. Not divided when a reset is performed.

# CONTENTS

|                                              |    |
|----------------------------------------------|----|
| 1. PIN FUNCTIONS .....                       | 15 |
| 1.1 LIST OF PIN FUNCTIONS .....              | 15 |
| 1.2 PROCESSING OF UNUSED PINS .....          | 17 |
| 2. MEMORY AND I/O CONFIGURATION .....        | 19 |
| 2.1 MEMORY SPACE .....                       | 19 |
| 2.2 I/O SPACE .....                          | 21 |
| 3. CPU .....                                 | 22 |
| 4. CG (CLOCK GENERATOR) .....                | 24 |
| 5. BIU (BUS INTERFACE UNIT) .....            | 24 |
| 6. BAU (BUS ARBITRATION UNIT) .....          | 25 |
| 7. WCU (WAIT CONTROL UNIT) .....             | 27 |
| 7.1 FEATURES .....                           | 27 |
| 7.2 RELATION BETWEEN WCU AND READY PIN ..... | 28 |
| 8. REFU (REFRESH CONTROL UNIT) .....         | 29 |
| 8.1 FEATURES .....                           | 29 |
| 8.2 REFRESH OPERATIONS .....                 | 29 |
| 9. TCU (TIMER/COUNTER UNIT) .....            | 30 |
| 9.1 FEATURES .....                           | 30 |
| 9.2 TCU INTERNAL BLOCK DIAGRAM .....         | 30 |
| 10. SCU (SERIAL CONTROL UNIT) .....          | 31 |
| 10.1 FEATURES .....                          | 31 |
| 10.2 SCU INTERNAL BLOCK DIAGRAM .....        | 31 |
| 11. ICU (INTERRUPT CONTROL UNIT) .....       | 32 |
| 11.1 FEATURES .....                          | 32 |
| 11.2 ICU INTERNAL BLOCK DIAGRAM .....        | 32 |
| 12. DMAU (DMA CONTROL UNIT) .....            | 33 |
| 12.1 FEATURES .....                          | 33 |
| 12.2 DMAU INTERNAL BLOCK DIAGRAM .....       | 33 |
| 13. STANDBY FUNCTIONS .....                  | 34 |
| 14. RESET OPERATION .....                    | 34 |
| 15. INSTRUCTION SET .....                    | 35 |

|                                                   |            |
|---------------------------------------------------|------------|
| <b>16. ELECTRICAL SPECIFICATIONS .....</b>        | <b>66</b>  |
| <b>16.1 AT 5 V OPERATION .....</b>                | <b>66</b>  |
| <b>16.2 AT 3 V OPERATION .....</b>                | <b>75</b>  |
| <b>17. PACKAGE DRAWINGS .....</b>                 | <b>100</b> |
| <b>18. RECOMMENDED SOLDERING CONDITIONS .....</b> | <b>103</b> |

## 1. PIN FUNCTIONS

### 1.1 LIST OF PIN FUNCTIONS

| Pin Name                                | Input/Output   | Function                                                    |
|-----------------------------------------|----------------|-------------------------------------------------------------|
| AD0 to AD15 <sup>Note 1, 3</sup>        | 3-state I/O    | Time-division address/data bus                              |
| AD0 to AD7 <sup>Note 2, 3</sup>         | 3-state I/O    | Time-division address/data bus                              |
| A8 to A15 <sup>Note 2, 3</sup>          | 3-state output | Address bus                                                 |
| A16/PS0 to A19/PS3 <sup>Note 3</sup>    | 3-state output | Time-division address/processor status                      |
| REFRQ                                   | Output         | Refresh request                                             |
| HLDRQ                                   | Input          | Bus hold request                                            |
| HLDACK                                  | Output         | Bus hold acknowledge                                        |
| RESET                                   | Input          | Reset                                                       |
| RESOUT                                  | Output         | System reset output                                         |
| READY                                   | Input          | Bus cycle end                                               |
| NMI                                     | Input          | Non-maskable interrupt                                      |
| MRD <sup>Note 3</sup>                   | 3-state output | Memory read strobe                                          |
| MWR <sup>Note 3</sup>                   | 3-state output | Memory read strobe                                          |
| IORD <sup>Note 3</sup>                  | 3-state output | I/O read strobe                                             |
| IOWR <sup>Note 3</sup>                  | 3-state output | I/O write strobe                                            |
| ASTB                                    | Output         | Address strobe                                              |
| UBE <sup>Note 1, 3</sup>                | 3-state output | Data bus upper byte enable                                  |
| High <sup>Note 2</sup>                  | 3-state output | High level output                                           |
| BUSLOCK <sup>Note 3</sup>               | 3-state output | Bus lock                                                    |
| POLL                                    | Input          | Floating-point operation processor polling                  |
| BUF $\overline{R}$ /W <sup>Note 3</sup> | 3-state output | Buffer read/write                                           |
| BUFEN <sup>Note 3</sup>                 | 3-state output | Buffer enable                                               |
| X1                                      | Input          | Crystal/external clock                                      |
| X2                                      | —              |                                                             |
| CLKOUT                                  | Output         | Clock output                                                |
| BS0 to BS2 <sup>Note 3</sup>            | 3-state output | Bus status                                                  |
| QS0, QS1                                | Output         | Queue status                                                |
| TOUT2                                   | Output         | Timer 2 output                                              |
| TCTL2                                   | Input          | Timer 2 control                                             |
| TCLK                                    | Input          | Timer clock                                                 |
| INTP1 to INTP7                          | Input          | Maskable interrupts                                         |
| INTAK/ $\overline{SRDY}$ /TOUT1         | Output         | Interrupt acknowledge/serial reception ready/timer 1 output |

**Notes** 1. V50HL only

2. V40HL only

3. These pins are provided with a latch. Therefore, when they go into a high-impedance state, they hold the status before the high-impedance state until driven by an external device. It is not necessary to pull up or down the data bus. To invert the level of the pin that goes into a high-impedance state by an external device, a drive current higher than the latch invert current ( $I_{ILH}$ ,  $I_{ILL}$ ) is necessary.

| Pin Name         | Input/Output | Function                                                 |
|------------------|--------------|----------------------------------------------------------|
| DMAAK3/TxD       | Output       | DMA acknowledge 3/serial transmit data                   |
| DMARQ3/RxD       | Input        | DMA request 3/serial receive data                        |
| DMAAK0 to DMAAK2 | Output       | DMA acknowledge                                          |
| DMARQ0 to DMARQ2 | Input        | DMA request                                              |
| END/TC           | I/O          | DMA service forcible termination/DMA service completion  |
| V <sub>DD</sub>  | —            | Positive power supply pin                                |
| GND              | —            | Ground potential pin                                     |
| IC               | —            | Internal connection pin (External connection impossible) |

## 1.2 PROCESSING OF UNUSED PINS

Table 1-1 shows the processing (recommended connection) of the unused pins. Use of a resistor with a resistance of 1 to 10 k $\Omega$  is recommended to connect these pins to V<sub>DD</sub> or GND via resistor.

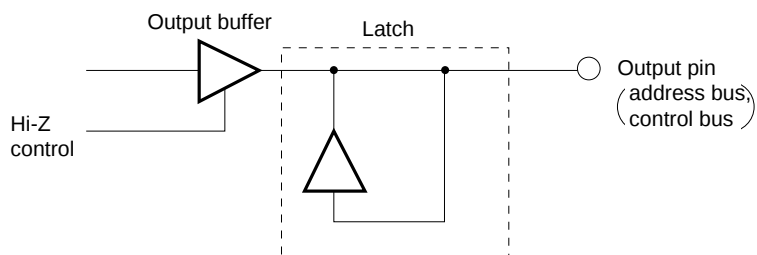
**Table 1-1. Processing of Unused Pins**

| Pin Name                      | Input/Output   | Recommended Connection                               |
|-------------------------------|----------------|------------------------------------------------------|
| AD0 to AD15 <sup>Note 1</sup> | 3-state I/O    | Open                                                 |
| AD0 to AD7 <sup>Note 2</sup>  | 3-state I/O    |                                                      |
| A8 to A15 <sup>Note 2</sup>   | 3-state output |                                                      |
| A16/PS0 to A19/PS3            | 3-state output |                                                      |
| REFRQ                         | Output         |                                                      |
| HLDRQ                         | Input          | Connect to GND via resistor                          |
| HLDK                          | Output         | Open                                                 |
| RESOUT                        | Output         | Open                                                 |
| READY                         | Input          | Connect to V <sub>DD</sub> via resistor              |
| NMI                           | Input          | Connect to GND via resistor                          |
| MRD                           | 3-state output | Open                                                 |
| MWR                           | 3-state output |                                                      |
| IOR                           | 3-state output |                                                      |
| IOWR                          | 3-state output |                                                      |
| ASTB                          | Output         |                                                      |
| UB <sup>Note 1</sup>          | 3-state output |                                                      |
| High <sup>Note 2</sup>        | Output         |                                                      |
| BUSLOCK                       | 3-state output |                                                      |
| POLL                          | Input          | Connect to GND via resistor                          |
| BUFR/W                        | 3-state output | Open                                                 |
| BUFEN                         | 3-state output |                                                      |
| CLKOUT                        | Output         | Open                                                 |
| BS0 to BS2                    | 3-state output |                                                      |
| QS0, QS1                      | Output         |                                                      |
| TOUT2                         | Output         |                                                      |
| TCTL2                         | Input          | Connect to GND via resistor                          |
| TCLK                          | Input          |                                                      |
| INTP1 to INTP7                | Input          | Open                                                 |
| INTAK/SRDY/TOUT1              | Output         |                                                      |
| DMAAK3/TxD                    | Output         |                                                      |
| DMARQ3/RxD                    | Input          | Connect to GND via resistor                          |
| DMAAK0 to DMAAK2              | Output         | Open                                                 |
| DMARQ0 to DMARQ2              | Input          | Connect to GND via resistor                          |
| END/TC                        | I/O            | Individually connect to V <sub>DD</sub> via resistor |

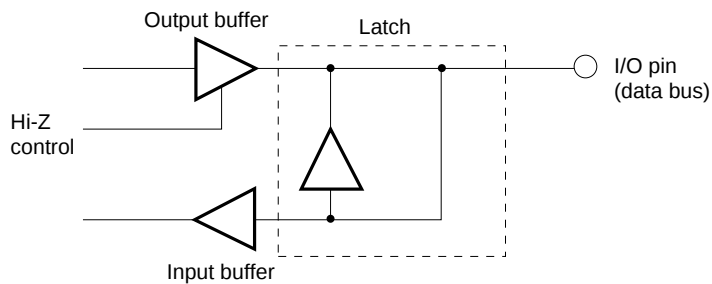
- Notes**
1. V50HL only
  2. V40HL only

**Remark** The circuit configuration of the latch is as illustrated below. To invert the level of the pin with a latch, a drive current higher than the latch invert current is necessary.

**(1) Output pin**



**(2) I/O pin**



## 2. MEMORY AND I/O CONFIGURATION

### 2.1 MEMORY SPACE

The V40HL and V50HL can access a 1M-byte (512K-word) memory space.

Figure 2-1. Memory Map

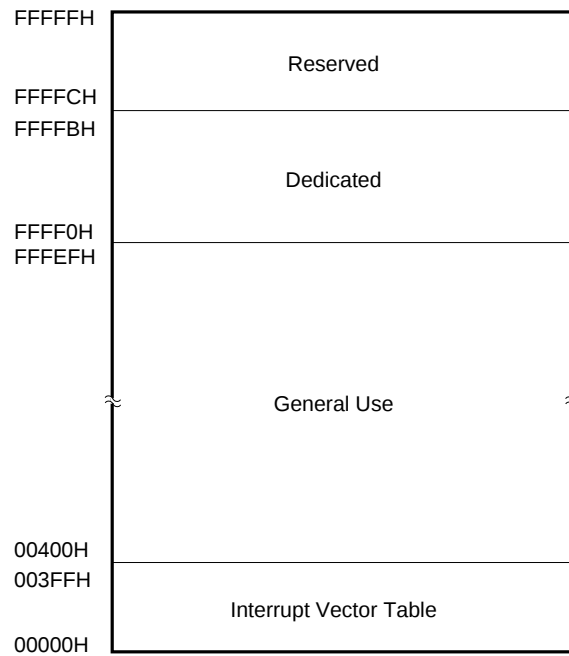


Figure 2-2. Interface with Memory (1/2)

#### (a) V40HL

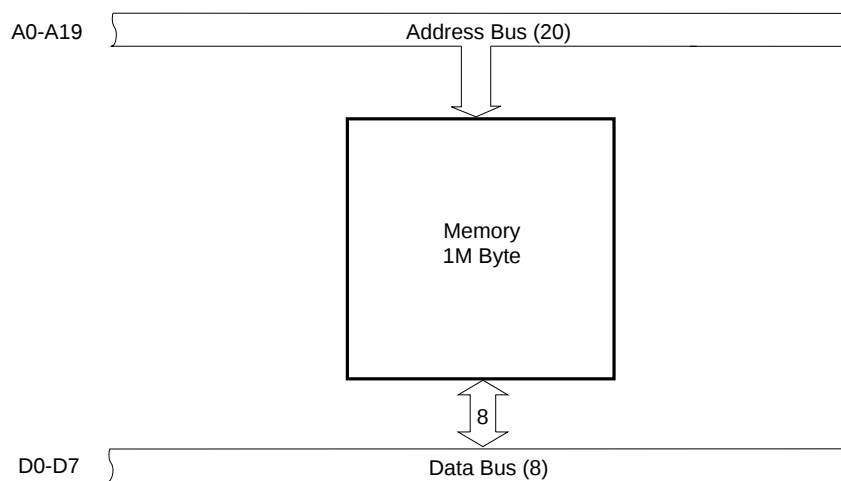
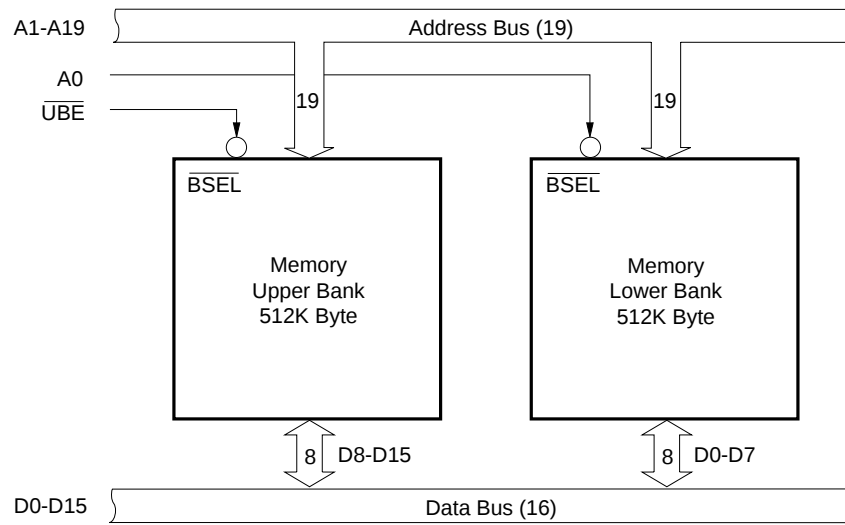


Figure 2-2. Interface with Memory (2/2)

(b) V50HL



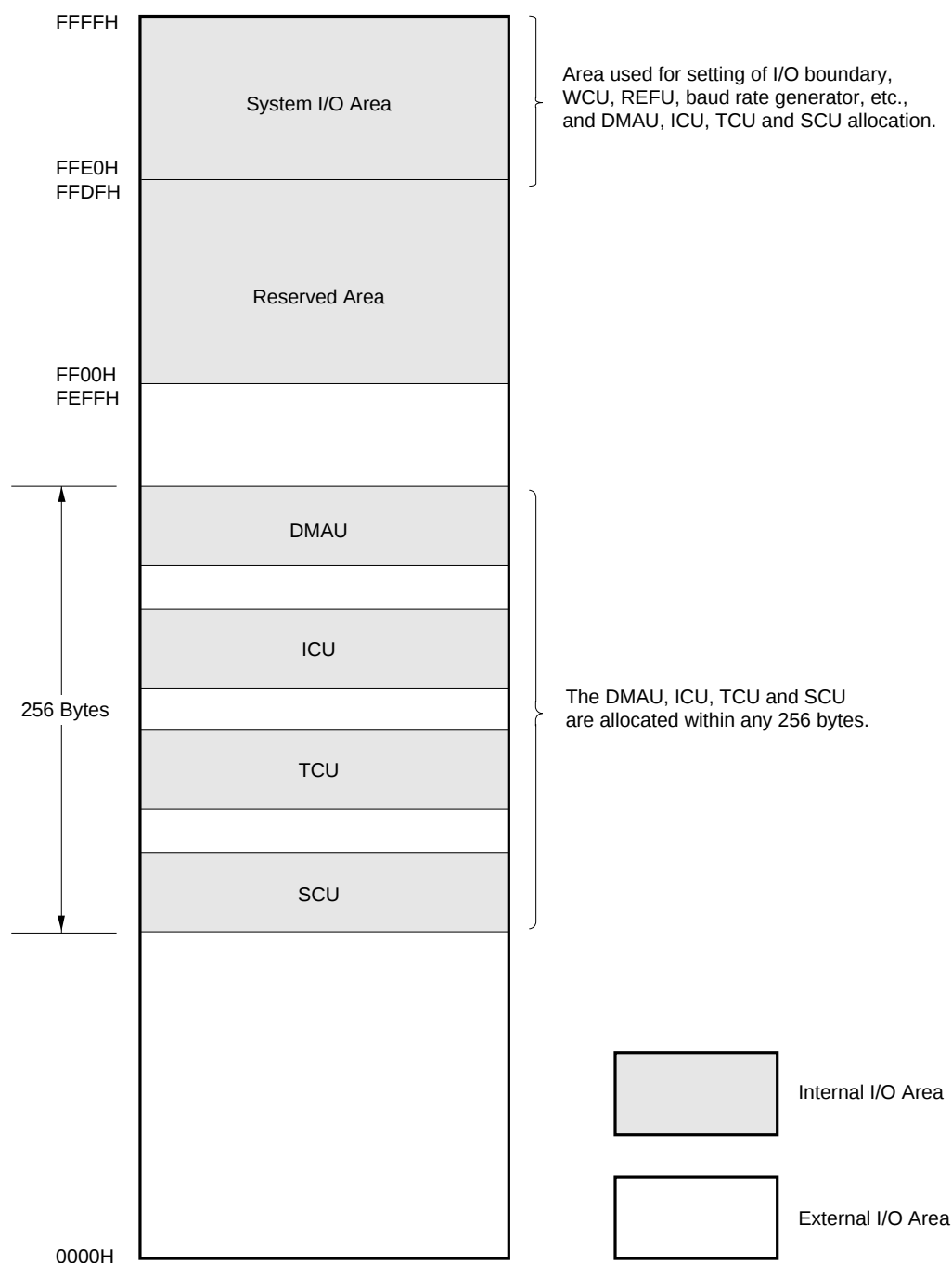
## 2.2 I/O SPACE

In the V40HL and V50HL, I/Os up to 64K bytes (32K words) can be accessed in an area independent of the memory. The various on-chip peripheral LSIs are set by accessing the system I/O area.

Extended functions added to those of the V40 and V50 are mapped onto unused V40 and V50 registers and the reserved area.

The I/O map is shown in Figure 2-3.

Figure 2-3. I/O Map



### 3. CPU

The CPU has the same functions as the V20HL™ and V30HL™. In hardware terms, there are some changes regarding the use of the bus with on-chip peripherals, but in software terms the CPU is fully compatible.

The internal block diagram of the CPU is shown in Figure 3-1.

**Figure 3-1. Internal Block Diagram of CPU (1/2)**

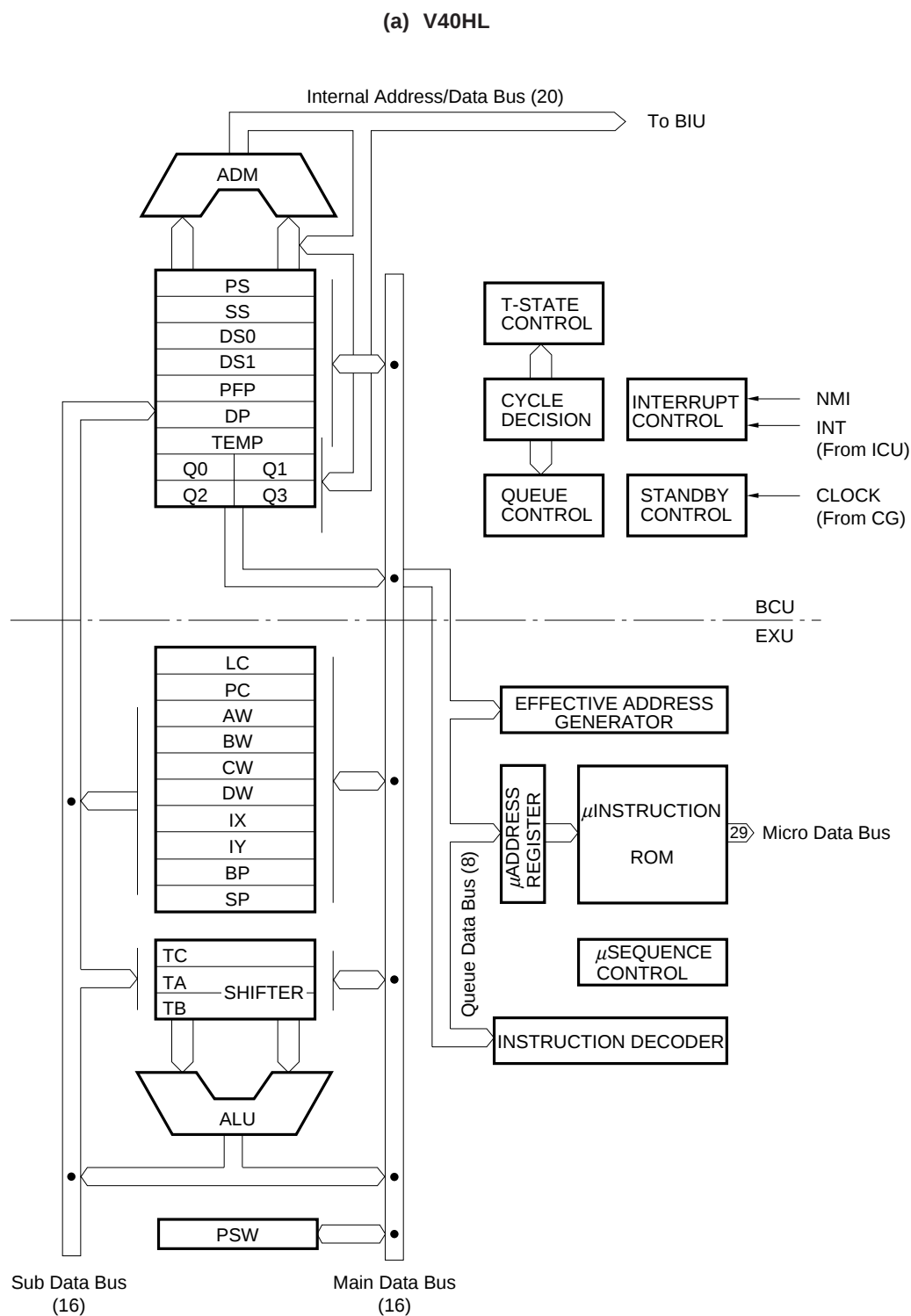
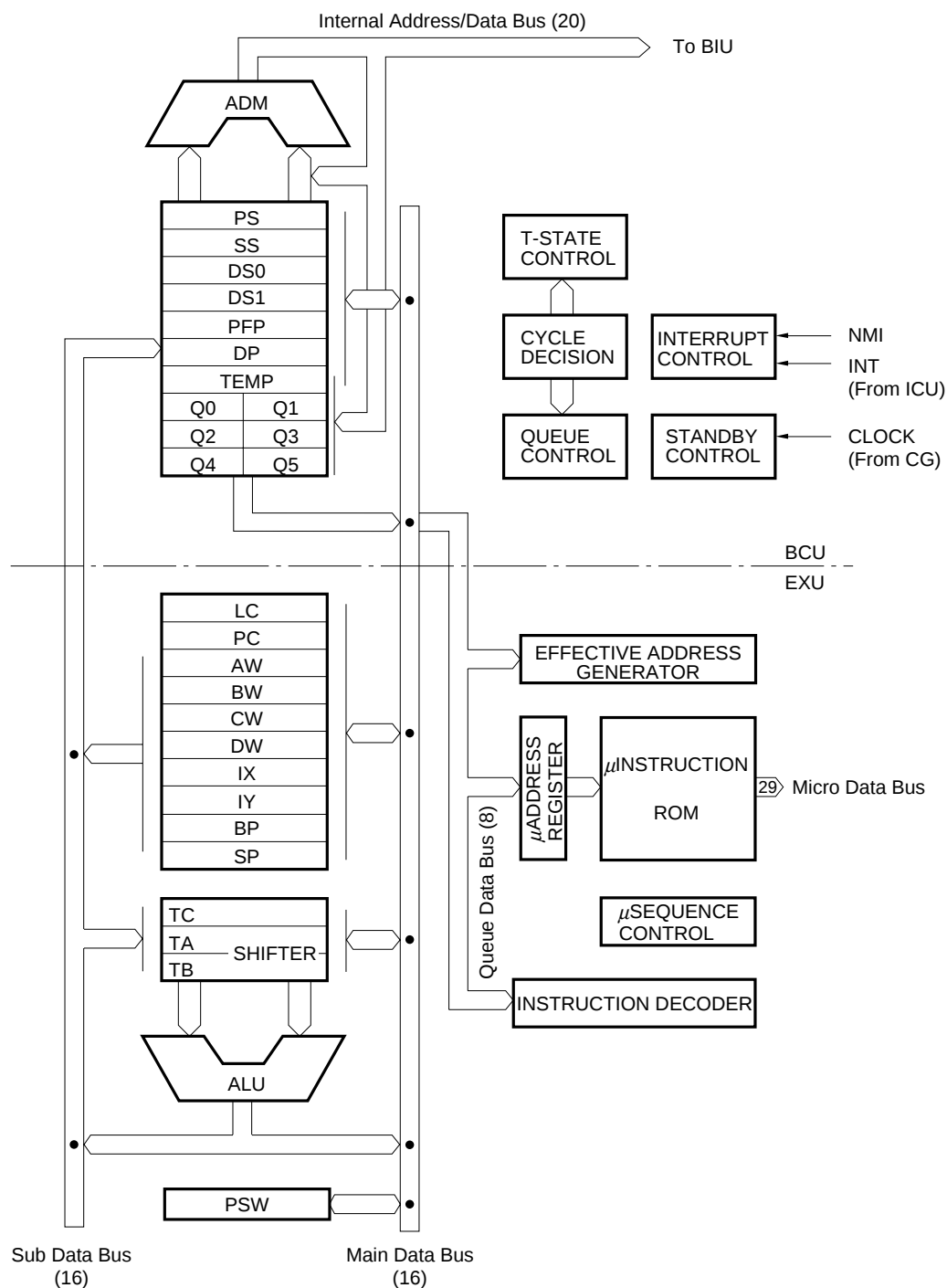


Figure 3-1. Internal Block Diagram of CPU (2/2)

(b) V50HL

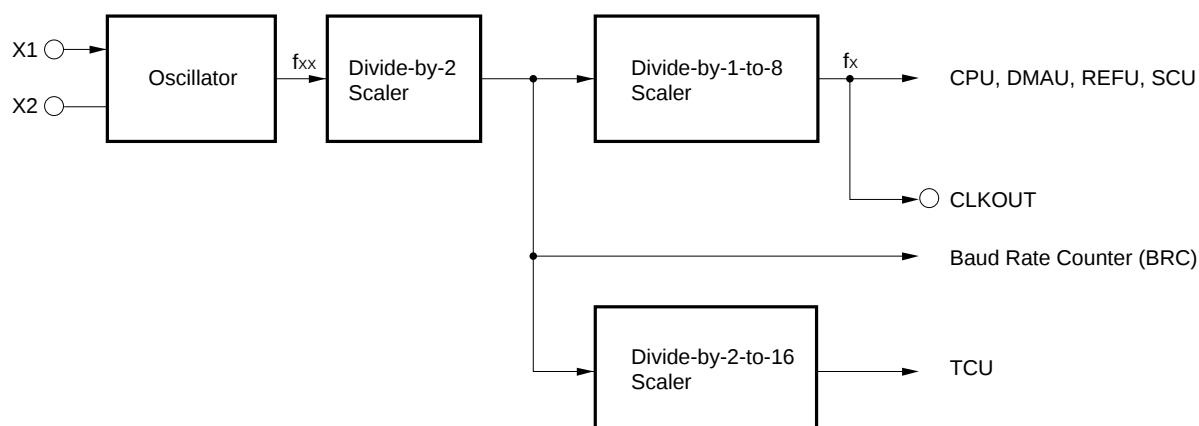


## 4. CG (CLOCK GENERATOR)

The CG generates a clock at a frequency of 1/2, 1/4, 1/8 or 1/16 that of the crystal and oscillator connected to the X1 and X2 pins, supplies it as the CPU operating clock and outputs it externally as the CLKOUT pin output.

The interrupt cycle time can be changed according to the oscillator scaling factor. The scaling factor can be set by a system I/O area register.

Figure 4-1. Internal Block Diagram of CG

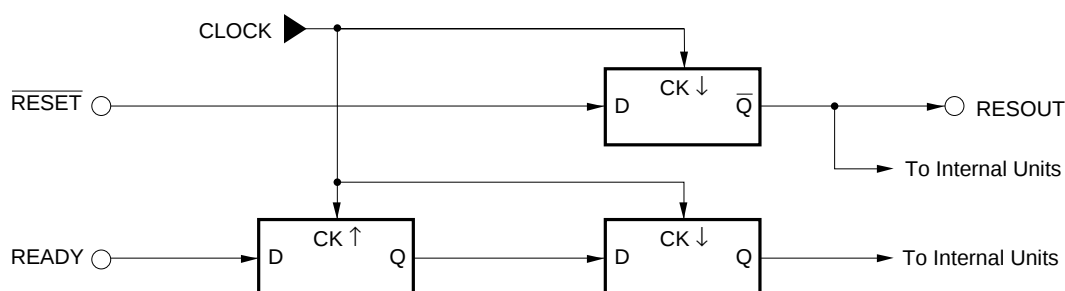


## 5. BIU (BUS INTERFACE UNIT)

The BIU controls the data bus, address bus and control bus pins. These buses are used by the CPU, DMAU (DMA control unit) and REFU (refresh control unit).

The BIU synchronizes the  $\overline{\text{RESET}}$  input signal and READY input signal using the CLOCK signal generated by the clock generator (CG). In addition to being supplied to the inside of the V40HL and V50HL, the synchronized reset signal is also output externally from the RESOUT pin. The synchronized READY signal is supplied to the internal CPU, DMAU and REFU.

Figure 5-1.  $\overline{\text{RESET}}$  and READY Signal Synchronization



## 6. BAU (BUS ARBITRATION UNIT)

The BAU performs bus arbitration among bus masters.

A list of bus masters (units which can acquire the bus) is shown below.

**Table 6-1. Bus Masters**

| Bus Master                               | Bus Cycle                           |
|------------------------------------------|-------------------------------------|
| CPU                                      | Program fetch, data read/write      |
| DMAU                                     | DMA cycle                           |
| REFU                                     | Refresh cycle                       |
| External bus master<br>(HLDRQ pin input) | Bus cycle driven by external device |

The relative priorities of the bus masters are shown below.

|      |                                                                    |
|------|--------------------------------------------------------------------|
| High | CPU (when BUSLOCK prefix is used)                                  |
|      | REFU (highest priority: when given number of requests are reached) |
|      | DMAU                                                               |
|      | HLDRQ pin                                                          |
|      | CPU (normal CPU cycle)                                             |
| Low  | REFU (lowest priority: cycle steal)                                |

BAU bus arbitration is performed as follows.

A bus master such as the CPU, DMAU, REFU, etc., incorporated in the V40HL and V50HL normally release the bus at the end of the bus cycle currently being executed, as shown in Figure 6-1. However, in the case of a bus master connected to the HLDRQ pin, or cascaded external DMA controllers, for instance, the situation is as shown in Figure 6-2. The V40HL and V50HL request return of the bus by inactivating the acknowledge signal (HLD AK), and on receiving this request, the external bus master holding the bus should release the bus by dropping the bus hold request signal (HLDRQ). The V40HL and V50HL-internal bus master with the highest priority is kept waiting until the bus hold request signal is dropped. This is called a bus wait operation.

Figure 6-1. Internal Bus Cycles

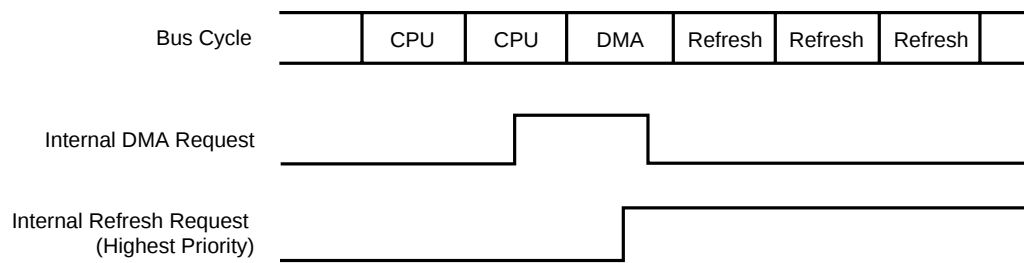
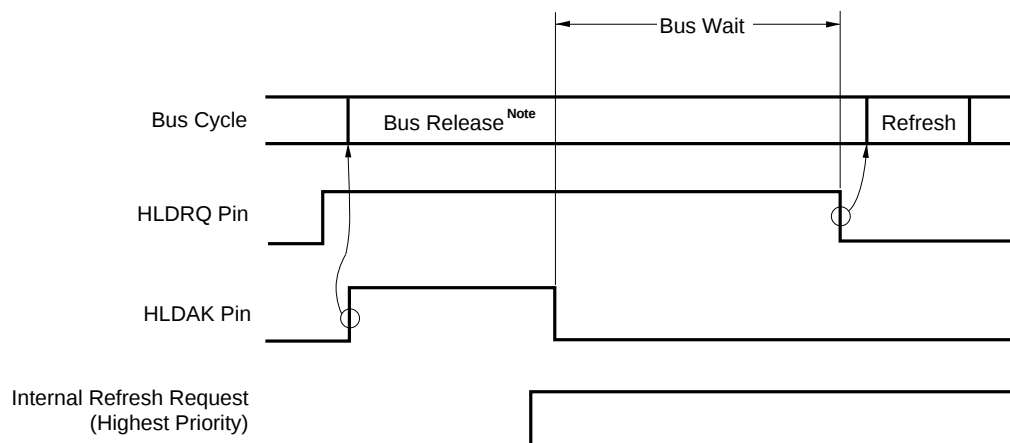


Figure 6-2. Bus Wait Operation



**Note** The period in which the external bus master which has been given the bus after its release by the V40HL and V50HL can use the bus.

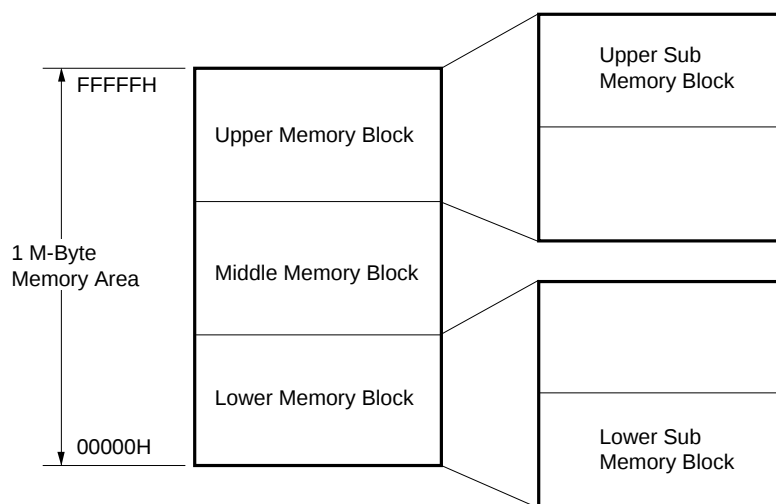
## 7. WCU (WAIT CONTROL UNIT)

The WCU has the function of automatically inserting a wait state (TW) of 0 to 3 clock cycles in a CPU, DMAU or REFU bus cycle.

### 7.1 FEATURES

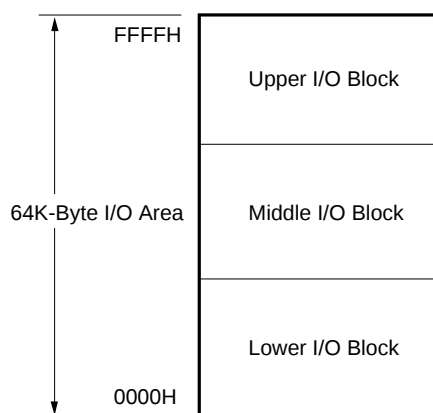
- Automatic setting of 0 to 3 waits for a CPU memory bus cycle
- 1M-byte memory space can be divided into 5
- 64K-byte I/O space can be divided into 3
- Automatic setting of 0 to 3 waits for an external I/O cycle
- Automatic setting of 0 to 3 waits for a DMA cycle
- Automatic setting of 0 to 3 waits for a refresh cycle
- Same as V40 and V50 directly after a reset (memory space divided into 3, no division of I/O space)

**Figure 7-1. Example of Memory Space Division**



**Remark** The division specification and the size of each block are set by means of a system I/O area register.

Figure 7-2. Example of I/O Space Division

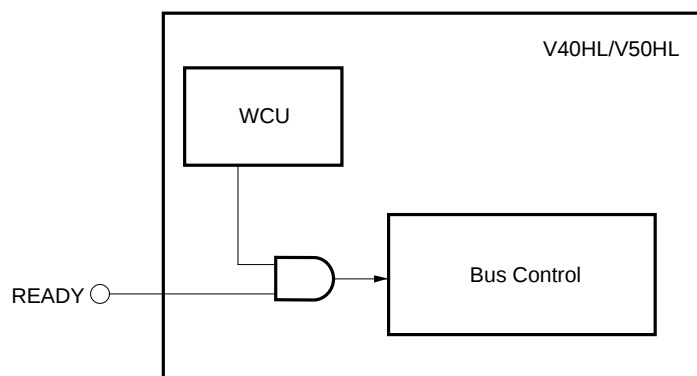


**Remark** The division specification and the size of each block are set by means of a system I/O area register.

## 7.2 RELATION BETWEEN WCU AND READY PIN

When wait cycles exceeding 3 clock cycles are necessary, the WCU and the READY signal pin can be used in combination. The number of wait cycles specified by the WCU set value or the number of wait cycles under READY control, whichever is larger, is inserted.

Figure 7-3. WCU and READY Control



## 8. REFU (REFRESH CONTROL UNIT)

The REFU generates refresh cycles required for refreshing of external DRAM. Refresh enabling/disabling and the refresh interval can be set programmably.

### 8.1 FEATURES

- Lowest-priority refreshing/highest-priority refreshing
- 7-refresh queue
- 16-bit refresh address
- $\overline{\text{REFRQ}}$  extended timing supported ( $\overline{\text{REFRQ}}$  active from T1 state)

### 8.2 REFRESH OPERATIONS

The REFU has two priorities. Normally, it has the lowest priority, and a refresh cycle cannot be started unless the bus is completely idle. However, if there are 7 or more pending refresh requests, it is given the highest priority, and it requests the bus master holding the bus to relinquish it. (See **6. BAU.**)

The refresh address is output on A0 to A15. Every refresh cycle the refresh address is incremented by 1 (for the V40HL) or by 2 (for the V50HL), and the next refresh address is generated.

In a refresh cycle, a low-level signal is output on the low address pins (A16 to A19).

This refresh address is not affected by a reset. When the device is powered on, the refresh address is undefined.

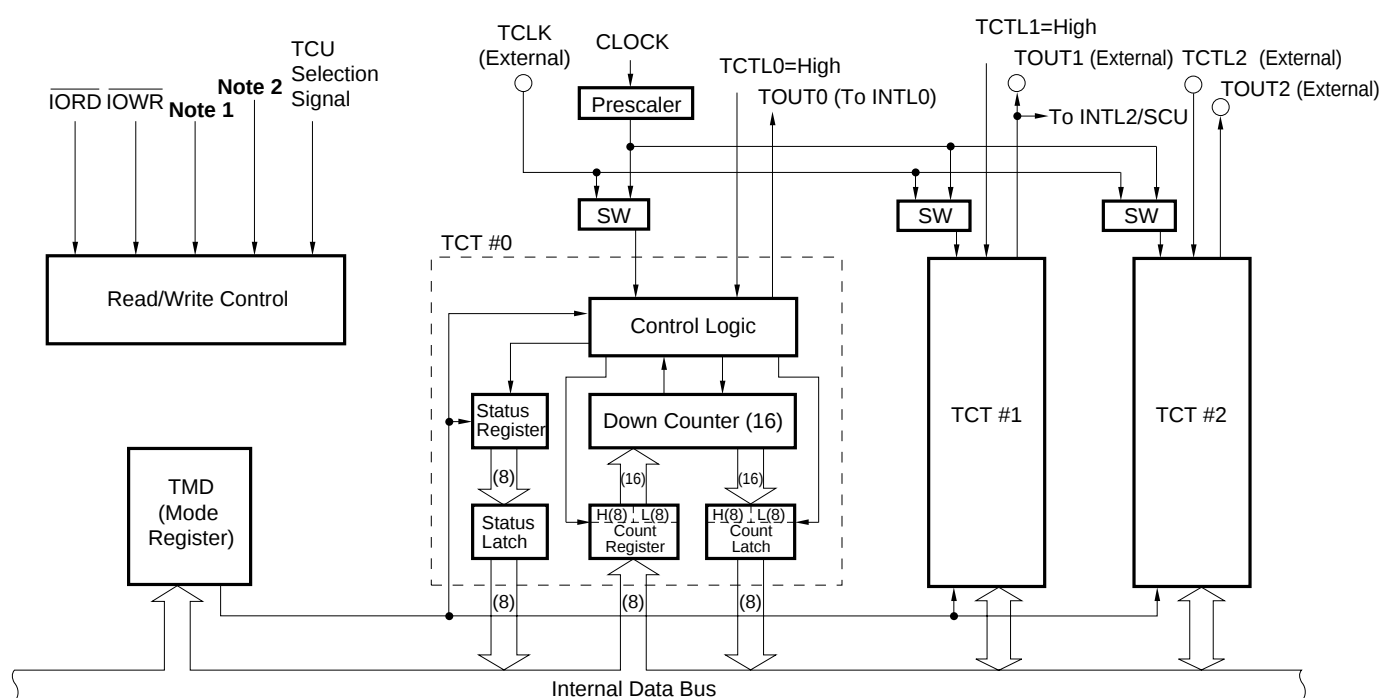
## 9. TCU (TIMER/COUNTER UNIT)

The TCU incorporates 3 counters, and can be used as a timer, event counter, rate generator, etc. Functionally it is a subset of the μPD71054.

### 9.1 FEATURES

- 3 × 16-bit counters
- Six programmable count modes
- Binary/BCD count
- Multiple latch command
- Choice of two input clocks: internal/external

### 9.2 TCU INTERNAL BLOCK DIAGRAM



**Notes** 1. A0 or A1 (Set by a system I/O area register)

2. A1 or A2 (Set by a system I/O area register)

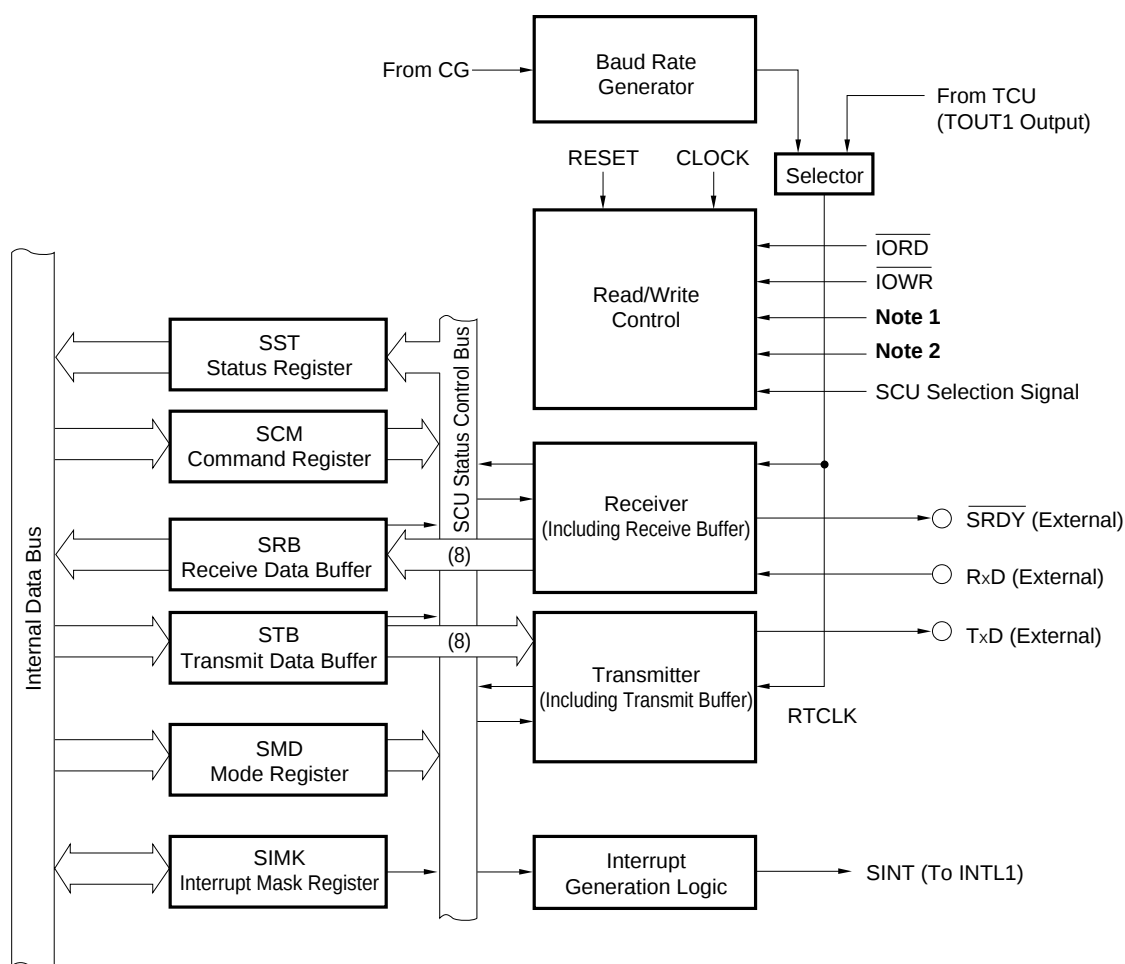
## 10. SCU (SERIAL CONTROL UNIT)

The SCU performs control of serial communication (asynchronous). Its functions are a subset of the μPD71051 excluding synchronous communication. Also, what was the control word register in the μPD71051 has been divided into two: a command register and a mode register.

### 10.1 FEATURES

- Dedicated baud rate generator incorporated (using internal clock)
- Asynchronous serial communication
- Clock rate: baud rate  $\times 16, \times 64$
- Baud rate: DC – 500 kbps
- Character length: 7/8 bits
- Transmit stop bits: 1/2 bits
- Break transmission
- Automatic break detection
- Full-duplex double-buffer system
- Parity addition/checking
- Error detection: parity, overrun, framing
- Interrupt generation maskable

### 10.2 SCU INTERNAL BLOCK DIAGRAM



**Notes 1.** A0 or A1 (Set by a system I/O area register)

**2.** A1 or A2 (Set by a system I/O area register)

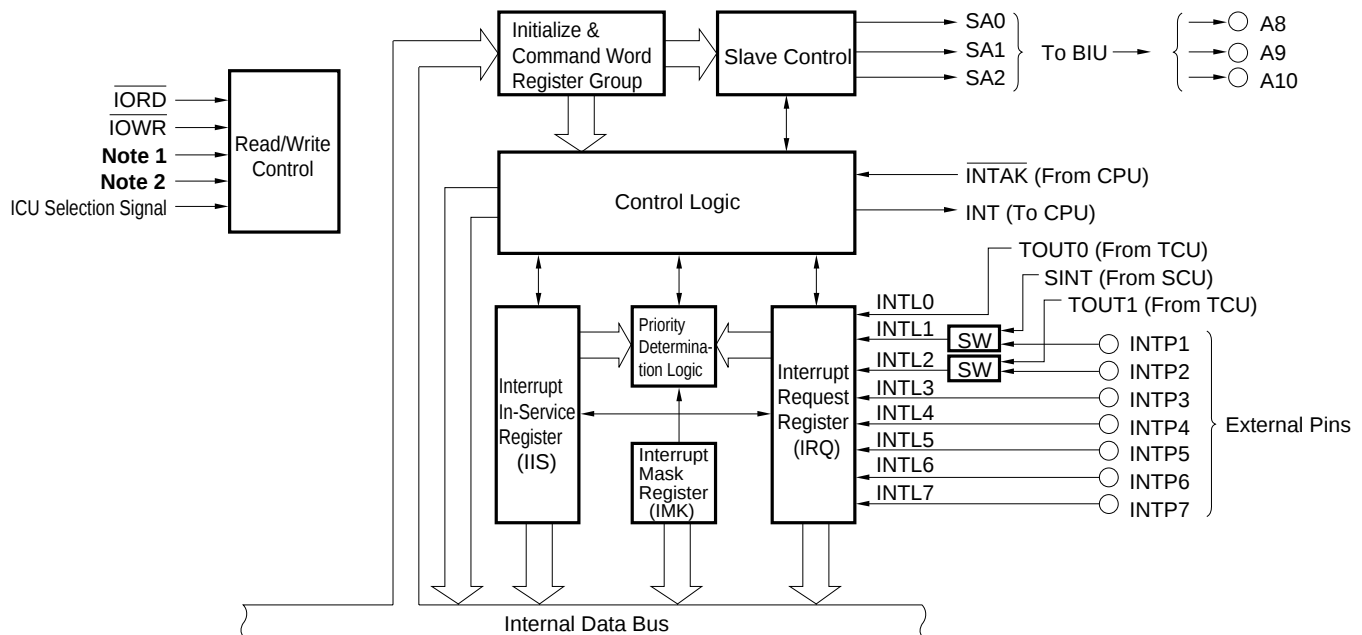
## 11. ICU (INTERRUPT CONTROL UNIT)

The ICU arbitrates among up to 8 interrupt requests (maskable interrupts) generated inside and outside the V40HL and V50HL, and transfers one of them to the CPU. The ICU functions comprise the functions of the V40HL and V50HL minus those functions not required by the V40HL and V50HL.

### 11.1 FEATURES

- 8 interrupt inputs
- μPD71059 cascading possible
- Edge- or level-triggered request input  
(input from internally connected TCU is edge-triggered only)
- Interrupt requests individually maskable
- Programmable interrupt request priority order
- Polling operation capability

### 11.2 ICU INTERNAL BLOCK DIAGRAM



- Notes**
1. A0 or A1 (Set by a system I/O area register)
  2. A1 or A2 (Set by a system I/O area register)

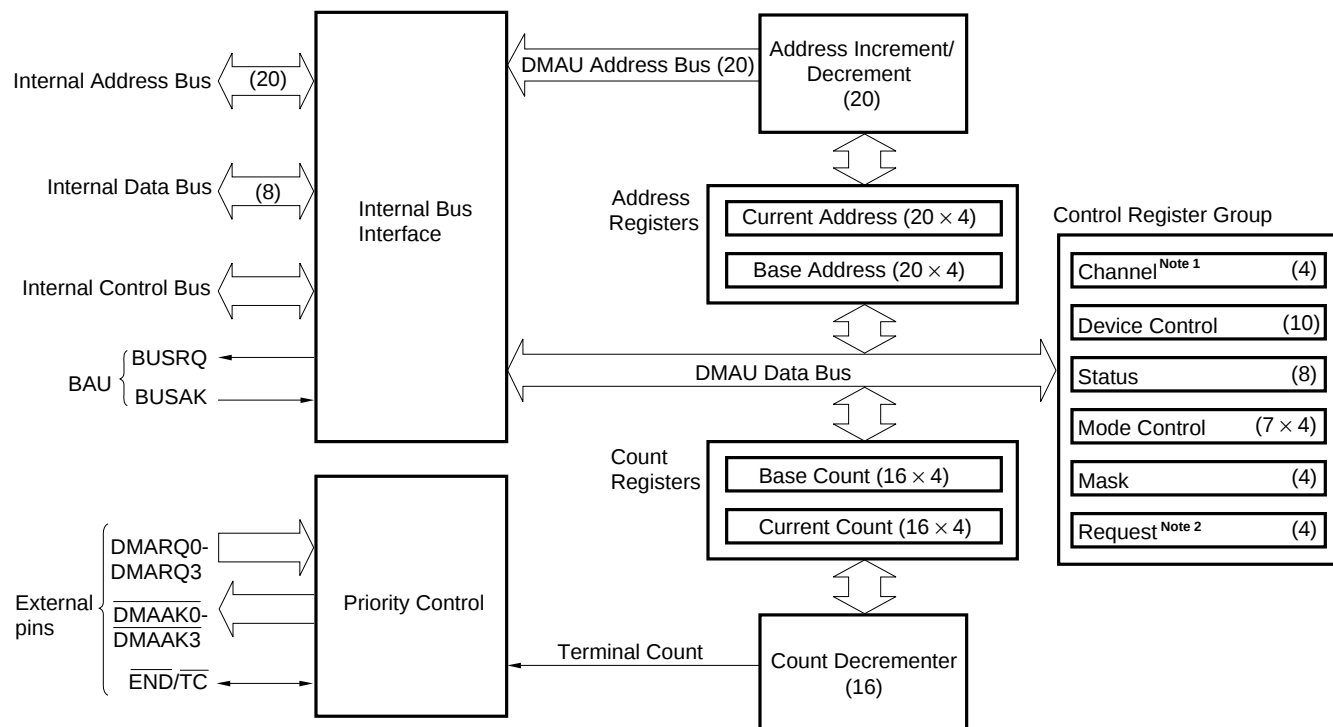
## 12. DMAU (DMA CONTROL UNIT)

The DMAU has 4 DMA channels, and provides the functions (subset) of two LSIs, the μPD71071 and μPD71037.

### 12.1 FEATURES

- Two operating modes (μPD71071 mode, μPD71037 mode)
- 20-bit address register
- 16-bit count register
- Four independent DMA channels
- Byte transfer/word transfer selectable
- Three transfer modes (settable on an individual channel basis)  
Single transfer mode, demand transfer mode, block transfer mode
- Two bus modes (common to all channels: in μPD71037 mode, bus release mode only)  
Bus release mode  
Bus hold mode
- DMA requests maskable on an individual channel basis
- Auto initialization function
- Transfer address increment/decrement
- Two channel priority systems (fixed priority/rotating priority)
- $\overline{TC}$  output at end of transfer
- Forced termination of service by  $\overline{END}$  input
- Cascading capability

### 12.2 DMAU INTERNAL BLOCK DIAGRAM



**Notes 1.** In μPD71071 mode

**2.** In μPD71037 mode

## 13. STANDBY FUNCTIONS

The V40HL and V50HL have two modes, the HALT mode and STOP mode, as standby functions.

### (1) HALT mode

When the HALT instruction is executed, the clock to internal CPU circuitry (excluding the HALT mode release circuit) is stopped.

### (2) STOP mode

When the HALT instruction is executed, all clocks to the CPU and internal I/Os are stopped.  
STOP mode should be used when a resonator is connected to the X1 and X2 pins.

**Remark** Switching between HALT mode and STOP mode is performed by setting a system I/O area register.

## 14. RESET OPERATION

When the  $\overline{\text{RESET}}$  pin is driven low and this level is held for 4 clock cycles or more from the fall of the signal, the CPU and on-chip peripheral LSIs are reset.

When the  $\overline{\text{RESET}}$  pin subsequently returns to the high level, the CPU begins an instruction prefetch from address FFFF0H.

When the V40HL and V50HL are reset, its status is fully compatible with the V40 and V50.

Extended functions added to those of the V40 and V50 are mapped onto unused V40 and V50 registers and the reserved area.

Table 14-1 shows the main statuses of the on-chip peripheral LSIs when a reset is performed.

**Table 14-1. Main Statuses of On-Chip Peripheral LSIs After Reset**

|      |                                                                                                                                   |
|------|-----------------------------------------------------------------------------------------------------------------------------------|
| WCU  | Memory, external I/O, DMA & refresh : 3-wait insertion<br>Upper & lower memory blocks : set to 512 KB                             |
| REFU | Refresh cycle : set to 72 clock cycles<br>Refresh enabling/disabling : not affected by reset                                      |
| SCU  | Baud rate : x 64<br>Character : 7 bits<br>Parity : None<br>Stop bits : 1 bit<br>Break detection : None                            |
| DMAU | μPD71071 mode<br>Demand mode<br>Auto initialization disabled<br>Verify transfer, byte transfer<br>Bus release mode<br>DMA enabled |

**Caution** When a reset is performed, the SCU, TCU, ICU and DMAU cannot be used.

## 15. INSTRUCTION SET

Table 15-1. Operand Type Legend

| Identifier  | Description                                                                                                                     |
|-------------|---------------------------------------------------------------------------------------------------------------------------------|
| reg         | 8/16-bit general register<br>(destination register in an instruction using two 8/16-bit general registers)                      |
| reg'        | Source register in an instruction using two 8/16-bit general registers                                                          |
| reg8        | 8-bit general register<br>(destination register in an instruction using two 8-bit general registers)                            |
| reg8'       | Source register in an instruction using two 8-bit general registers                                                             |
| reg16       | 16-bit general register<br>(destination register in an instruction using two 16-bit general registers)                          |
| reg16'      | Source register in an instruction using two 16-bit general registers                                                            |
| dmem        | 8/16-bit memory location                                                                                                        |
| mem         | 8/16-bit memory location                                                                                                        |
| mem8        | 8-bit memory location                                                                                                           |
| mem16       | 16-bit memory location                                                                                                          |
| mem32       | 32-bit memory location                                                                                                          |
| imm         | Constant in range 0 to FFFFH                                                                                                    |
| imm3        | Constant in range 0 to 7                                                                                                        |
| imm4        | Constant in range 0 to FH                                                                                                       |
| imm8        | Constant in range 0 to FFH                                                                                                      |
| imm16       | Constant in range 0 to FFFFH                                                                                                    |
| acc         | Accumulator AW or AL                                                                                                            |
| sreg        | Segment register                                                                                                                |
| src-table   | Name of 256-byte conversion translation table                                                                                   |
| src-block   | Name of block addressed by register IX                                                                                          |
| dst-block   | Name of block addressed by register IY                                                                                          |
| near-proc   | Procedure in current program segment                                                                                            |
| far-proc    | Procedure in a different program segment                                                                                        |
| near-label  | Label in current program segment                                                                                                |
| short-label | Label in range -128 to +127 bytes from end of instruction                                                                       |
| far-label   | Label in a different program segment                                                                                            |
| memptr16    | Word containing location offset in a different program segment to which control is to be shifted and segment base address       |
| memptr32    | Doubleword containing location offset in a different program segment to which control is to be shifted and segment base address |
| regptr16    | General register containing location offset in a different program segment to which control is to be shifted                    |
| pop-value   | Number of bytes to be removed from stack (0 to 64K, normally an even number)                                                    |
| fp-op       | Immediate value which identifies external floating-point operation coprocessor operation code                                   |
| R           | Register set                                                                                                                    |

Table 15-2. Operation Code Legend

| Identifier       | Description                                                                                                                 |
|------------------|-----------------------------------------------------------------------------------------------------------------------------|
| W                | Byte/word specification bit (0: byte, 1: word). However, when s =1, byte data of sign extension is 16-bit operand if W = 1. |
| reg              | Register field (000 to 111)                                                                                                 |
| reg'             | Register field (000 to 111) (source register in instruction which uses two registers)                                       |
| mem              | Memory field (000 to 111)                                                                                                   |
| mod              | Mode field (00 to 10)                                                                                                       |
| s                | Sign-extended specification bit (0: without sign extension, 1: with sign extension)                                         |
| X, XXX, YYY, ZZZ | Data used to determine external floating-point coprocessor operation code                                                   |

Table 15-3. Operand Description Legend

| Identifier | Description                                     |
|------------|-------------------------------------------------|
| AW         | Accumulator (16-bit)                            |
| AH         | Accumulator (high-order byte)                   |
| AL         | Accumulator (low-order byte)                    |
| BW         | Register BW (16-bit)                            |
| CW         | Register CW (16-bit)                            |
| CL         | Register CL (low-order byte)                    |
| DW         | Register DW (16-bit)                            |
| BP         | Base pointer (16-bit)                           |
| SP         | Stack pointer (16-bit)                          |
| PC         | Program counter (16-bit)                        |
| PSW        | Program status word (16-bit)                    |
| IX         | Index register (source) (16-bit)                |
| IY         | Index register (destination) (16-bit)           |
| PS         | Program segment register (16-bit)               |
| SS         | Stack segment register (16-bit)                 |
| DS0        | Data segment 0 register (16-bit)                |
| DS1        | Data segment 1 register (16-bit)                |
| AC         | Auxiliary carry flag                            |
| CY         | Carry flag                                      |
| P          | Parity flag                                     |
| S          | Sign flag                                       |
| Z          | Zero flag                                       |
| DIR        | Direction flag                                  |
| IE         | Interrupt enable flag                           |
| V          | Overflow flag                                   |
| BRK        | Break flag                                      |
| MD         | Mode flag                                       |
| (...)      | Contents of memory indicated by contents of ( ) |
| disp       | Displacement (8/16-bit)                         |
| ext-disp8  | 16 bits with 8-bit displacement sign-extended   |
| temp       | Temporary register (8/16/32-bit)                |
| TA         | Temporary register A (16-bit)                   |
| TB         | Temporary register B (16-bit)                   |
| TC         | Temporary register C (16-bit)                   |
| tmpcy      | Temporary carry flag (1-bit)                    |
| seg        | Immediate segment data (16-bit)                 |
| offset     | Immediate offset data (16-bit)                  |
| ←          | Transfer direction                              |
| +          | Addition                                        |
| −          | Subtraction                                     |
| ×          | Multiplication                                  |
| ÷          | Division                                        |
| %          | Modulo                                          |
| ^          | Logical product                                 |
| ∨          | Logical sum                                     |
| ⊕          | Exclusive logical sum                           |
| xxH        | Two-digit hexadecimal number                    |
| xxxxH      | Four-digit hexadecimal number                   |

**Table 15-4. Flag Operation Legend**

| Identifier | Description                          |
|------------|--------------------------------------|
| (Blank)    | No change                            |
| 0          | Cleared to 0                         |
| 1          | Set to 1                             |
| ×          | Set or cleared depending upon result |
| U          | Undefined                            |
| R          | Previously saved value is restored   |

**Table 15-5. Memory Addressing**

| mod<br>mem | 00             | 01               | 10                |
|------------|----------------|------------------|-------------------|
| 000        | BW + IX        | BW + IX + disp 8 | BW + IX + disp 16 |
| 001        | BW + IY        | BW + IY + disp 8 | BW + IY + disp 16 |
| 010        | BP + IX        | BP + IX + disp 8 | BP + IX + disp 16 |
| 011        | BP + IY        | BP + IY + disp 8 | BP + IY + disp 16 |
| 100        | IX             | IX + disp 8      | IX + disp 16      |
| 101        | IY             | IY + disp 8      | IY + disp 16      |
| 110        | DIRECT ADDRESS | BP + disp 8      | BP + disp 16      |
| 111        | BW             | BW + disp 8      | BW + disp 16      |

**Table 15-6. 8/16-Bit General Register Selection**

| reg, reg' | W=0 | W=1 |
|-----------|-----|-----|
| 000       | AL  | AW  |
| 001       | CL  | CW  |
| 010       | DL  | DW  |
| 011       | BL  | BW  |
| 100       | AH  | SP  |
| 101       | CH  | BP  |
| 110       | DH  | IX  |
| 111       | BH  | IY  |

**Table 15-7. Segment Register Selection**

| sreg |     |
|------|-----|
| 00   | DS1 |
| 01   | PS  |
| 10   | SS  |
| 11   | DS0 |

The instruction set is shown in tabular form on the following pages.

Clock cycle shown in table is the time required for execution of instruction by the execution unit and is based on the following conditions.

- Prefetch time and wait time for using bus, etc. are not included.
- 0 wait is assumed for memory access. That is, the clock number of one bus cycle is four clock cycle.
- 0 wait is assumed for I/O access.
- Primitive block transfer instruction and primitive input/output instruction is included repeat prefixes.

The number of clock cycle of instruction with byte processing and word processing (with W bit) is shown as the followings.

#### (1) V40HL

On the left of "/" : The value corresponding to byte processing (W= 0) or word processing (W = 1) of even address

On the right of "/": The value corresponding to word processing (W =1) of odd address

For the clock of block transfer related instruction of V40HL, see **Table 15-8**.

**Table 15-8. Number of Clock Cycles in Block Transfer Related Instruction (V40HL)**

| Instruction | Number of Clock Cycles             |                                    |
|-------------|------------------------------------|------------------------------------|
|             | Byte Processing (W = 0)            | Word Processing (W = 1)            |
| MOVBK       | $9 + 8 \times \text{rep}$<br>(9)   | $9 + 16 \times \text{rep}$<br>(17) |
| CMPBK       | $7 + 14 \times \text{rep}$<br>(13) | $7 + 22 \times \text{rep}$<br>(21) |
| CMPM        | $7 + 10 \times \text{rep}$<br>(7)  | $7 + 14 \times \text{rep}$<br>(11) |
| LDM         | $7 + 9 \times \text{rep}$<br>(7)   | $7 + 13 \times \text{rep}$<br>(11) |
| STM         | $5 + 4 \times \text{rep}$<br>(5)   | $5 + 8 \times \text{rep}$<br>(9)   |
| INM         | $9 + 8 \times \text{rep}$<br>(10)  | $9 + 16 \times \text{rep}$<br>(18) |
| OUTM        | $9 + 8 \times \text{rep}$<br>(10)  | $9 + 16 \times \text{rep}$<br>(18) |

**Remark** The figures in parentheses apply to one-time processing only.

(2) V50HL

On the left of "/" : The value corresponding to byte processing (W= 0) or word processing (W = 1) of even address

On the right of "/" : The value corresponding to word processing (W =1) of odd address

For the clock of block transfer related instruction of V50HL, see **Table 15-9**.

**Table 15-9. Number of Clock Cycles in Block Transfer Related Instruction V50HL (1/2)**

| Instruction | Number of Clock Cycles             |                                    |                                    |                                    |
|-------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
|             | Byte Processing<br>(W = 0)         | Word Processing (W = 1)            |                                    |                                    |
|             |                                    | Odd/Odd Address                    | Odd/Even Address                   | Even/Even Address                  |
| MOVBK       | $9 + 8 \times \text{rep}$<br>(9)   | $9 + 16 \times \text{rep}$<br>(17) | $9 + 12 \times \text{rep}$<br>(13) | $9 + 8 \times \text{rep}$<br>(9)   |
| CMPBK       | $7 + 14 \times \text{rep}$<br>(13) | $7 + 22 \times \text{rep}$<br>(21) | $7 + 18 \times \text{rep}$<br>(17) | $7 + 14 \times \text{rep}$<br>(13) |
| INM         | $9 + 8 \times \text{rep}$<br>(10)  | $9 + 16 \times \text{rep}$<br>(18) | $9 + 12 \times \text{rep}$<br>(14) | $9 + 8 \times \text{rep}$<br>(10)  |
| OUTM        | $9 + 8 \times \text{rep}$<br>(10)  | $9 + 16 \times \text{rep}$<br>(18) | $9 + 12 \times \text{rep}$<br>(14) | $9 + 8 \times \text{rep}$<br>(10)  |

**Remark** The figures in parentheses apply to one-time processing only.

**Table 15-9. Number of Clock Cycles in Block Transfer Related Instruction (V50HL) (2/2)**

| Instruction | Number of Clock Cycles            |                                    |                                   |
|-------------|-----------------------------------|------------------------------------|-----------------------------------|
|             | Byte Processing<br>(W = 0)        | Word Processing (W = 1)            |                                   |
|             |                                   | Odd Address                        | Even Address                      |
| CMPM        | $7 + 10 \times \text{rep}$<br>(7) | $7 + 14 \times \text{rep}$<br>(11) | $7 + 10 \times \text{rep}$<br>(7) |
| LDM         | $7 + 9 \times \text{rep}$<br>(7)  | $7 + 13 \times \text{rep}$<br>(11) | $7 + 9 \times \text{rep}$<br>(7)  |
| STM         | $5 + 4 \times \text{rep}$<br>(5)  | $5 + 8 \times \text{rep}$<br>(9)   | $5 + 4 \times \text{rep}$<br>(5)  |

**Remark** The figures in parentheses apply to one-time processing only.

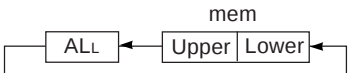
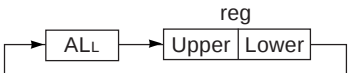
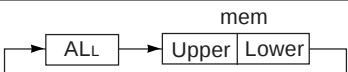
| Instruction Group          | Mnemonic | Operand(s)             | Operation Code  |                 | Bytes | Clock Cycles |       | Operation                                                   | Flags |    |   |   |   |   |
|----------------------------|----------|------------------------|-----------------|-----------------|-------|--------------|-------|-------------------------------------------------------------|-------|----|---|---|---|---|
|                            |          |                        | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL |                                                             | AC    | CY | V | P | S | Z |
| Data transfer instructions | MOV      | reg, reg'              | 1 0 0 0 1 0 1 W | 1 1 reg reg'    | 2     | 2            | 2     | reg ← reg'                                                  |       |    |   |   |   |   |
|                            |          | mem, reg               | 1 0 0 0 1 0 0 W | mod reg mem     | 2-4   | 7/11         | 7/11  | (mem) ← reg                                                 |       |    |   |   |   |   |
|                            |          | reg, mem               | 1 0 0 0 1 0 1 W | mod reg mem     | 2-4   | 10/14        | 10/14 | reg ← (mem)                                                 |       |    |   |   |   |   |
|                            |          | mem, imm               | 1 1 0 0 0 1 1 W | mod 0 0 0 mem   | 3-6   | 9/13         | 9/13  | (mem) ← imm                                                 |       |    |   |   |   |   |
|                            |          | reg, imm               | 1 0 1 1 W reg   |                 | 2-3   | 4            | 4     | reg ← imm                                                   |       |    |   |   |   |   |
|                            |          | acc, dmem              | 1 0 1 0 0 0 0 W |                 | 3     | 10/14        | 10/14 | If W=0: AL ← (dmem)<br>If W=1: AH ← (dmem + 1), AL ← (dmem) |       |    |   |   |   |   |
|                            |          | dmem, acc              | 1 0 1 0 0 0 1 W |                 | 3     | 9/13         | 9/13  | If W=0: (dmem) ← AL<br>If W=1: (dmem + 1) ← AH, (dmem) ← AL |       |    |   |   |   |   |
|                            |          | sreg, reg16            | 1 0 0 0 1 1 1 0 | 1 1 0 sreg reg  | 2     | 2            | 2     | sreg ← reg16 sreg:SS, DS0, DS1                              |       |    |   |   |   |   |
|                            |          | sreg, mem16            | 1 0 0 0 1 1 1 0 | mod 0 sreg mem  | 2-4   | 14           | 10/14 | sreg ← (mem16) sreg:SS, DS0, DS1                            |       |    |   |   |   |   |
|                            |          | reg16, sreg            | 1 0 0 0 1 1 0 0 | 1 1 0 sreg reg  | 2     | 2            | 2     | reg16 ← sreg                                                |       |    |   |   |   |   |
|                            |          | mem16, sreg            | 1 0 0 0 1 1 0 0 | mod 0 sreg mem  | 2-4   | 12           | 8/12  | (mem16) ← sreg                                              |       |    |   |   |   |   |
|                            |          | DS0, reg16, mem32      | 1 1 0 0 0 1 0 1 | mod reg mem     | 2-4   | 25           | 17/25 | reg16 ← (mem32)<br>DS0 ← (mem32 + 2)                        |       |    |   |   |   |   |
|                            |          | DS1, reg16, mem32      | 1 1 0 0 0 1 0 0 | mod reg mem     | 2-4   | 25           | 17/25 | reg16 ← (mem32)<br>DS1 ← (mem32 + 2)                        |       |    |   |   |   |   |
|                            |          | AH, PSW                | 1 0 0 1 1 1 1 1 |                 | 1     | 2            | 2     | AH ← S, Z, ×, AC, ×, P, ×, CY                               |       |    |   |   |   |   |
|                            |          | PSW, AH                | 1 0 0 1 1 1 1 0 |                 | 1     | 3            | 3     | S, Z, ×, AC, ×, P, ×, CY ← AH                               | ×     | ×  |   | × | × | × |
|                            | LDEA     | reg16, mem16           | 1 0 0 0 1 1 0 1 | mod reg mem     | 2-4   | 4            | 4     | reg16 ← mem16                                               |       |    |   |   |   |   |
|                            | TRANS    | src-table              | 1 1 0 1 0 1 1 1 |                 | 1     | 9            | 9     | AL ← (BW + AL)                                              |       |    |   |   |   |   |
|                            | XCH      | reg, reg'              | 1 0 0 0 0 1 1 W | 1 1 reg reg'    | 2     | 3            | 3     | reg ↔ reg'                                                  |       |    |   |   |   |   |
|                            |          | mem, reg<br>reg, mem   | 1 0 0 0 0 1 1 W | mod reg mem     | 2-4   | 13/21        | 13/21 | (mem) ↔ reg                                                 |       |    |   |   |   |   |
|                            |          | AW, reg16<br>reg16, AW | 1 0 0 1 0 reg   |                 | 1     | 3            | 3     | AW ↔ reg16                                                  |       |    |   |   |   |   |

| Instruction Group                     | Mnemonic      | Operand(s)                  | Operation Code  |                 | Bytes | Clock Cycles         |                      | Operation                                                                                                                                                                                                                                                       | Flags |    |   |   |   |   |
|---------------------------------------|---------------|-----------------------------|-----------------|-----------------|-------|----------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                                       |               |                             | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL                | V50HL                |                                                                                                                                                                                                                                                                 | AC    | CY | V | P | S | Z |
| Repeat prefixes                       | REPC          |                             | 0 1 1 0 0 1 0 1 |                 | 1     | 2                    | 2                    | While CW ≠ 0, the following byte primitive block transfer instruction is executed and CW is decremented (−1).<br>If there is a pending interrupt, it is serviced.<br>If CY ≠ 1 the loop is exited.                                                              |       |    |   |   |   |   |
|                                       | REPNC         |                             | 0 1 1 0 0 1 0 0 |                 | 1     | 2                    | 2                    | Same as above<br>If CY ≠ 0 the loop is exited.                                                                                                                                                                                                                  |       |    |   |   |   |   |
|                                       | REP           |                             | 1 1 1 1 0 0 1 1 |                 | 1     | 2                    | 2                    | While CW ≠ 0, the following byte primitive block transfer instruction is executed and CW is decremented (−1).<br>If there is a pending interrupt, it is serviced.<br>If the primitive block transfer instruction is CMPBK or CMPM and Z ≠ 1 the loop is exited. |       |    |   |   |   |   |
|                                       | REPE          |                             |                 |                 |       |                      |                      |                                                                                                                                                                                                                                                                 |       |    |   |   |   |   |
|                                       | REPZ          |                             |                 |                 |       |                      |                      |                                                                                                                                                                                                                                                                 |       |    |   |   |   |   |
|                                       | REPNE<br>REPZ |                             | 1 1 1 1 0 0 1 0 |                 | 1     | 2                    | 2                    | Same as above<br>If Z ≠ 0 the loop is exited.                                                                                                                                                                                                                   |       |    |   |   |   |   |
| Primitive block transfer instructions | MOVBK         | dst-block,<br><br>src-block | 1 0 1 0 0 1 0 W |                 | 1     | See<br>Table<br>15-8 | See<br>Table<br>15-9 | If W = 0: (IY) ← (IX)<br>DIR = 0 : IX ← IX + 1, IY ← IY + 1<br>DIR = 1 : IX ← IX − 1, IY ← IY − 1                                                                                                                                                               |       |    |   |   |   |   |
|                                       |               |                             |                 |                 |       |                      |                      | If W = 1: (IY + 1, IY) ← (IX + 1, IX)<br>DIR = 0 : IX ← IX + 2, IY ← IY + 2<br>DIR = 1 : IX ← IX − 2, IY ← IY − 2                                                                                                                                               |       |    |   |   |   |   |
|                                       | CMPBK         | src-block,<br><br>dst-block | 1 0 1 0 0 1 1 W |                 | 1     | See<br>Table<br>15-8 | See<br>Table<br>15-9 | If W = 0: (IX) − (IY)<br>DIR = 0 : IX ← IX + 1, IY ← IY + 1<br>DIR = 1 : IX ← IX − 1, IY ← IY − 1                                                                                                                                                               | ×     | ×  | × | × | × | × |
|                                       |               |                             |                 |                 |       |                      |                      | If W = 1: (IX + 1, IX) − (IY + 1, IY)<br>DIR = 0 : IX ← IX + 2, IY ← IY + 2<br>DIR = 1 : IX ← IX − 2, IY ← IY − 2                                                                                                                                               |       |    |   |   |   |   |
|                                       | CMPM          | dst-block                   | 1 0 1 0 1 1 1 W |                 | 1     | See<br>Table<br>15-8 | See<br>Table<br>15-9 | If W = 0: AL − (IY)<br>DIR = 0 : IY ← IY + 1; DIR = 1 : IY ← IY − 1                                                                                                                                                                                             | ×     | ×  | × | × | × | × |
|                                       |               |                             |                 |                 |       |                      |                      | If W = 1: AW − (IY + 1, IY)<br>DIR = 0 : IY ← IY + 2; DIR = 1 : IY ← IY − 2                                                                                                                                                                                     |       |    |   |   |   |   |
|                                       | LDM           | src-block                   | 1 0 1 0 1 1 0 W |                 | 1     | See<br>Table<br>15-8 | See<br>Table<br>15-9 | If W = 0: AL ← (IX)<br>DIR = 0 : IX ← IX + 1; DIR = 1 : IX ← IX − 1                                                                                                                                                                                             |       |    |   |   |   |   |
|                                       |               |                             |                 |                 |       |                      |                      | If W = 1: AW ← (IX + 1, IX)<br>DIR = 0 : IX + 2; DIR = 1 : IX ← IX − 2                                                                                                                                                                                          |       |    |   |   |   |   |
|                                       | STM           | dst-block                   | 1 0 1 0 1 0 1 W |                 | 1     | See<br>Table<br>15-8 | See<br>Table<br>15-9 | If W = 0: (IY) ← AL<br>DIR = 0 : IY ← IY + 1; DIR = 1 : IY ← IY − 1                                                                                                                                                                                             |       |    |   |   |   |   |
|                                       |               |                             |                 |                 |       |                      |                      | If W = 1: (IY + 1, IY) ← AW<br>DIR = 0 : IY ← IY + 2; DIR = 1 : IY ← IY − 2                                                                                                                                                                                     |       |    |   |   |   |   |

| Instruction Group                   | Mnemonic | Operand(s)    | Operation Code  |                 | Bytes | Clock Cycles   |                      | Operation                                                                              | Flags |    |   |   |   |   |
|-------------------------------------|----------|---------------|-----------------|-----------------|-------|----------------|----------------------|----------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                                     |          |               | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL          | V50HL                |                                                                                        | AC    | CY | V | P | S | Z |
| Bit field manipulation instructions | INS      | reg8, reg8'   | 0 0 0 0 1 1 1 1 | 0 0 1 1 0 0 0 1 | 3     | 35-133         | 31-117/<br>35-133    | 16-bit field ← AW                                                                      |       |    |   |   |   |   |
|                                     |          |               | 1 1 reg' reg    |                 |       |                |                      |                                                                                        |       |    |   |   |   |   |
|                                     |          | reg8, imm4    | 0 0 0 0 1 1 1 1 | 0 0 1 1 1 0 0 1 | 4     | 35-133         | 31-117/<br>35-133    | 16-bit field ← AW                                                                      |       |    |   |   |   |   |
|                                     |          |               | 1 1 0 0 0 reg   |                 |       |                |                      |                                                                                        |       |    |   |   |   |   |
|                                     | EXT      | reg8, reg8'   | 0 0 0 0 1 1 1 1 | 0 0 1 1 0 0 1 1 | 3     | 34-59          | 26-55/<br>34-59      | AW ← 16-bit field                                                                      |       |    |   |   |   |   |
|                                     |          |               | 1 1 reg' reg    |                 |       |                |                      |                                                                                        |       |    |   |   |   |   |
|                                     |          | reg8, imm4    | 0 0 0 0 1 1 1 1 | 0 0 1 1 1 0 1 1 | 4     | 34-59          | 26-55/<br>34-59      | AW ← 16-bit field                                                                      |       |    |   |   |   |   |
|                                     |          |               | 1 1 0 0 0 reg   |                 |       |                |                      |                                                                                        |       |    |   |   |   |   |
| Input/output instructions           | IN       | acc, imm8     | 1 1 1 0 0 1 0 W |                 | 2     | 9/13           | 9/13 <sup>Note</sup> | If W = 0: AL ← (imm8)<br>If W = 1: AH ← (imm8 + 1), AL ← (imm8)                        |       |    |   |   |   |   |
|                                     |          | acc, DW       | 1 1 1 0 1 1 0 W |                 | 1     | 8/12           | 8/12 <sup>Note</sup> | If W = 0: AL ← (DW)<br>If W = 1: AH ← (DW + 1), AL ← (DW)                              |       |    |   |   |   |   |
|                                     | OUT      | imm8, acc     | 1 1 1 0 0 1 1 W |                 | 2     | 8/12           | 8/12 <sup>Note</sup> | If W = 0: (imm8) ← AL<br>If W = 1: (imm8 + 1) ← AH, (imm8) ← AL                        |       |    |   |   |   |   |
|                                     |          | DW, acc       | 1 1 1 0 1 1 1 W |                 | 1     | 8/12           | 8/12 <sup>Note</sup> | If W = 0: (DW) ← AL<br>If W = 1: (DW + 1) ← AH, (DW) ← AL                              |       |    |   |   |   |   |
| Primitive input/output instructions | INM      | dst-block, DW | 0 1 1 0 1 1 0 W |                 | 1     | See Table 15-8 | See Table 15-9       | If W = 0: (IY) ← (DW)<br>DIR = 0 : IY ← IY + 1 ; DIR = 1 : IY ← IY - 1                 |       |    |   |   |   |   |
|                                     |          |               |                 |                 |       |                |                      | If W = 1: (IY + 1, IY) ← (DW + 1, DW)<br>DIR = 0 : IY ← IY + 2 ; DIR = 1 : IY ← IY - 2 |       |    |   |   |   |   |
|                                     | OUTM     | DW, src-block | 0 1 1 0 1 1 1 W |                 | 1     | See Table 15-8 | See Table 15-9       | If W = 0: (DW) ← (IX)<br>DIR = 0 : IX ← IX + 1 ; DIR = 1 : IX ← IX - 1                 |       |    |   |   |   |   |
|                                     |          |               |                 |                 |       |                |                      | If W = 1: (DW + 1, DW) ← (IX + 1, IX)<br>DIR = 0 : IX ← IX + 2 ; DIR = 1 : IX ← IX - 2 |       |    |   |   |   |   |

**Note** In case of IN/OUT instruction to internal DMAU, the number of word processing clock cycles applied is always that to the right of "/".

| Instruction Group                 | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |       | Operation                                                                                                                                  | Flags |    |   |   |   |   |
|-----------------------------------|----------|------------|-----------------|-----------------|-------|--------------|-------|--------------------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                                   |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL |                                                                                                                                            | AC    | CY | V | P | S | Z |
| Addition/subtraction instructions | ADD      | reg, reg'  | 0 0 0 0 0 0 1 W | 1 1 reg reg'    | 2     | 2            | 2     | $\text{reg} \leftarrow \text{reg} + \text{reg}'$                                                                                           | x     | x  | x | x | x | x |
|                                   |          | mem, reg   | 0 0 0 0 0 0 0 W | mod reg mem     | 2-4   | 13/21        | 13/21 | $(\text{mem}) \leftarrow (\text{mem}) + \text{reg}$                                                                                        | x     | x  | x | x | x | x |
|                                   |          | reg, mem   | 0 0 0 0 0 0 1 W | mod reg mem     | 2-4   | 10/14        | 10/14 | $\text{reg} \leftarrow \text{reg} + (\text{mem})$                                                                                          | x     | x  | x | x | x | x |
|                                   |          | reg, imm   | 1 0 0 0 0 0 s W | 1 1 0 0 0 reg   | 3-4   | 4            | 4     | $\text{reg} \leftarrow \text{reg} + \text{imm}$                                                                                            | x     | x  | x | x | x | x |
|                                   |          | mem, imm   | 1 0 0 0 0 0 s W | mod 0 0 0 mem   | 3-6   | 15/23        | 15/23 | $(\text{mem}) \leftarrow (\text{mem}) + \text{imm}$                                                                                        | x     | x  | x | x | x | x |
|                                   |          | acc, imm   | 0 0 0 0 0 1 0 W |                 | 2-3   | 4            | 4     | If W = 0: $\text{AL} \leftarrow \text{AL} + \text{imm}$<br>If W = 1: $\text{AW} \leftarrow \text{AW} + \text{imm}$                         | x     | x  | x | x | x | x |
|                                   | ADDC     | reg, reg'  | 0 0 0 1 0 0 1 W | 1 1 reg reg'    | 2     | 2            | 2     | $\text{reg} \leftarrow \text{reg} + \text{reg}' + \text{CY}$                                                                               | x     | x  | x | x | x | x |
|                                   |          | mem, reg   | 0 0 0 1 0 0 0 W | mod reg mem     | 2-4   | 13/21        | 13/21 | $(\text{mem}) \leftarrow (\text{mem}) + \text{reg} + \text{CY}$                                                                            | x     | x  | x | x | x | x |
|                                   |          | reg, mem   | 0 0 0 1 0 0 1 W | mod reg mem     | 2-4   | 10/14        | 10/14 | $\text{reg} \leftarrow \text{reg} + (\text{mem}) + \text{CY}$                                                                              | x     | x  | x | x | x | x |
|                                   |          | reg, imm   | 1 0 0 0 0 0 s W | 1 1 0 1 0 reg   | 3-4   | 4            | 4     | $\text{reg} \leftarrow \text{reg} + \text{imm} + \text{CY}$                                                                                | x     | x  | x | x | x | x |
|                                   |          | mem, imm   | 1 0 0 0 0 0 s W | mod 0 1 0 mem   | 3-6   | 15/23        | 15/23 | $(\text{mem}) \leftarrow (\text{mem}) + \text{imm} + \text{CY}$                                                                            | x     | x  | x | x | x | x |
|                                   |          | acc, imm   | 0 0 0 1 0 1 0 W |                 | 2-3   | 4            | 4     | If W = 0: $\text{AL} \leftarrow \text{AL} + \text{imm} + \text{CY}$<br>If W = 1: $\text{AW} \leftarrow \text{AW} + \text{imm} + \text{CY}$ | x     | x  | x | x | x | x |
|                                   | SUB      | reg, reg'  | 0 0 1 0 1 0 1 W | 1 1 reg reg'    | 2     | 2            | 2     | $\text{reg} \leftarrow \text{reg} - \text{reg}'$                                                                                           | x     | x  | x | x | x | x |
|                                   |          | mem, reg   | 0 0 1 0 1 0 0 W | mod reg mem     | 2-4   | 13/21        | 13/21 | $(\text{mem}) \leftarrow (\text{mem}) - \text{reg}$                                                                                        | x     | x  | x | x | x | x |
|                                   |          | reg, mem   | 0 0 1 0 1 0 1 W | mod reg mem     | 2-4   | 10/14        | 10/14 | $\text{reg} \leftarrow \text{reg} - (\text{mem})$                                                                                          | x     | x  | x | x | x | x |
|                                   |          | reg, imm   | 1 0 0 0 0 0 s W | 1 1 1 0 1 reg   | 3-4   | 4            | 4     | $\text{reg} \leftarrow \text{reg} - \text{imm}$                                                                                            | x     | x  | x | x | x | x |
|                                   |          | mem, imm   | 1 0 0 0 0 0 s W | mod 1 0 1 mem   | 3-6   | 15/23        | 15/23 | $(\text{mem}) \leftarrow (\text{mem}) - \text{imm}$                                                                                        | x     | x  | x | x | x | x |
|                                   |          | acc, imm   | 0 0 1 0 1 1 0 W |                 | 2-3   | 4            | 4     | If W = 0: $\text{AL} \leftarrow \text{AL} - \text{imm}$<br>If W = 1: $\text{AW} \leftarrow \text{AW} - \text{imm}$                         | x     | x  | x | x | x | x |
|                                   | SUBC     | reg, reg'  | 0 0 0 1 1 0 1 W | 1 1 reg reg'    | 2     | 2            | 2     | $\text{reg} \leftarrow \text{reg} - \text{reg}' - \text{CY}$                                                                               | x     | x  | x | x | x | x |
|                                   |          | mem, reg   | 0 0 0 1 1 0 0 W | mod reg mem     | 2-4   | 13/21        | 13/21 | $(\text{mem}) \leftarrow (\text{mem}) - \text{reg} - \text{CY}$                                                                            | x     | x  | x | x | x | x |
|                                   |          | reg, mem   | 0 0 0 1 1 0 1 W | mod reg mem     | 2-4   | 10/14        | 10/14 | $\text{reg} \leftarrow \text{reg} - (\text{mem}) - \text{CY}$                                                                              | x     | x  | x | x | x | x |
|                                   |          | reg, imm   | 1 0 0 0 0 0 s W | 1 1 0 1 1 reg   | 3-4   | 4            | 4     | $\text{reg} \leftarrow \text{reg} - \text{imm} - \text{CY}$                                                                                | x     | x  | x | x | x | x |
|                                   |          | mem, imm   | 1 0 0 0 0 0 s W | mod 0 1 1 mem   | 3-6   | 15/23        | 15/23 | $(\text{mem}) \leftarrow (\text{mem}) - \text{imm} - \text{CY}$                                                                            | x     | x  | x | x | x | x |
|                                   |          | acc, imm   | 0 0 0 1 1 1 0 W |                 | 2-3   | 4            | 4     | If W = 0: $\text{AL} \leftarrow \text{AL} - \text{imm} - \text{CY}$<br>If W = 1: $\text{AW} \leftarrow \text{AW} - \text{imm} - \text{CY}$ | x     | x  | x | x | x | x |

| Instruction Group                | Mnemonic | Operand(s) | Operation Code                   |                 | Bytes | Clock Cycles      |                   | Operation                                                                           | Flags |    |   |   |   |   |
|----------------------------------|----------|------------|----------------------------------|-----------------|-------|-------------------|-------------------|-------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                                  |          |            | 7 6 5 4 3 2 1 0                  | 7 6 5 4 3 2 1 0 |       | V40HL             | V50HL             |                                                                                     | AC    | CY | V | P | S | Z |
| BCD operation instructions       | ADD4S    |            | 0 0 0 0 1 1 1 1                  | 0 0 1 0 0 0 0 0 | 2     | $19 \times n + 7$ | $19 \times n + 7$ | dst BCD string $\leftarrow$ dst BCD string + src BCD string*                        | U     | ×  | U | U | U | × |
|                                  | SUB4S    |            | 0 0 0 0 1 1 1 1                  | 0 0 1 0 0 0 1 0 | 2     | $19 \times n + 7$ | $19 \times n + 7$ | dst BCD string $\leftarrow$ dst BCD string – src BCD string*                        | U     | ×  | U | U | U | × |
|                                  | CMP4S    |            | 0 0 0 0 1 1 1 1                  | 0 0 1 0 0 1 1 0 | 2     | $19 \times n + 7$ | $19 \times n + 7$ | dst BCD string – src BCD string*                                                    | U     | ×  | U | U | U | × |
|                                  | ROL4     | reg8       | 0 0 0 0 1 1 1 1<br>1 1 0 0 0 reg | 0 0 1 0 1 0 0 0 | 3     | 13                | 13                |  |       |    |   |   |   |   |
|                                  |          | mem8       | 0 0 0 0 1 1 1 1<br>mod 0 0 0 mem | 0 0 1 0 1 0 0 0 | 3-5   | 25                | 25                |  |       |    |   |   |   |   |
|                                  | ROR4     | reg8       | 0 0 0 0 1 1 1 1<br>1 1 0 0 0 reg | 0 0 1 0 1 0 1 0 | 3     | 17                | 17                |  |       |    |   |   |   |   |
|                                  |          | mem8       | 0 0 0 0 1 1 1 1<br>mod 0 0 0 mem | 0 0 1 0 1 0 1 0 | 3-5   | 29                | 29                |  |       |    |   |   |   |   |
| Increment/decrement instructions | INC      | reg8       | 1 1 1 1 1 1 1 0                  | 1 1 0 0 0 reg   | 2     | 2                 | 2                 | reg8 $\leftarrow$ reg8 + 1                                                          | ×     |    | × | × | × | × |
|                                  |          | mem        | 1 1 1 1 1 1 1 W                  | mod 0 0 0 mem   | 2-4   | 13/21             | 13/21             | (mem) $\leftarrow$ (mem) + 1                                                        | ×     |    | × | × | × | × |
|                                  |          | reg16      | 0 1 0 0 0 reg                    |                 | 1     | 2                 | 2                 | reg16 $\leftarrow$ reg16 + 1                                                        | ×     |    | × | × | × | × |
|                                  | DEC      | reg8       | 1 1 1 1 1 1 1 0                  | 1 1 0 0 1 reg   | 2     | 2                 | 2                 | reg8 $\leftarrow$ reg8 – 1                                                          | ×     |    | × | × | × | × |
|                                  |          | mem        | 1 1 1 1 1 1 1 W                  | mod 0 0 1 mem   | 2-4   | 13/21             | 13/21             | (mem) $\leftarrow$ (mem) – 1                                                        | ×     |    | × | × | × | × |
|                                  |          | reg16      | 0 1 0 0 1 reg                    |                 | 1     | 2                 | 2                 | reg16 $\leftarrow$ reg16 – 1                                                        | ×     |    | × | × | × | × |

n: 1/2 the number of BCD digits

\* The number of BCD digits is given by the CL register: a value between 1 and 254 can be set.

| Instruction Group           | Mnemonic | Operand(s)                                   | Operation Code  |                 | Bytes | Clock Cycles |                 | Operation                                                                                               | Flags |    |   |   |   |   |
|-----------------------------|----------|----------------------------------------------|-----------------|-----------------|-------|--------------|-----------------|---------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                             |          |                                              | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL           |                                                                                                         | AC    | CY | V | P | S | Z |
| Multiplication instructions | MULU     | reg8                                         | 1 1 1 1 0 1 1 0 | 1 1 1 0 0 reg   | 2     | 21-22        | 21-22           | AW ← AL × reg8<br>AH = 0: CY ← 0, V ← 0<br>AH ≠ 0: CY ← 1, V ← 1                                        | U     | ×  | × | U | U | U |
|                             |          | mem8                                         | 1 1 1 1 0 1 1 0 | mod 1 0 0 mem   | 2-4   | 26-27        | 26-27           | AW ← AL × (mem8)<br>AH = 0: CY ← 0, V ← 0<br>AH ≠ 0: CY ← 1, V ← 1                                      | U     | ×  | × | U | U | U |
|                             |          | reg16                                        | 1 1 1 1 0 1 1 1 | 1 1 1 0 0 reg   | 2     | 29-30        | 29-30           | DW, AW ← AW × reg16<br>DW = 0: CY ← 0, V ← 0<br>DW ≠ 0: CY ← 1, V ← 1                                   | U     | ×  | × | U | U | U |
|                             |          | mem16                                        | 1 1 1 1 0 1 1 1 | mod 1 0 0 mem   | 2-4   | 38-39        | 34-35/<br>38-39 | DW, AW ← AW × (mem16)<br>DW = 0: CY ← 0, V ← 0<br>DW ≠ 0: CY ← 1, V ← 1                                 | U     | ×  | × | U | U | U |
|                             | MUL      | reg8                                         | 1 1 1 1 0 1 1 0 | 1 1 1 0 1 reg   | 2     | 33-39        | 33-39           | AW ← AL × reg8<br>AH = AL sign extension: CY ← 0, V ← 0<br>AH ≠ AL sign extension: CY ← 1, V ← 1        | U     | ×  | × | U | U | U |
|                             |          | mem8                                         | 1 1 1 1 0 1 1 0 | mod 1 0 1 mem   | 2-4   | 38-44        | 38-44           | AW ← AL × (mem8)<br>AH = AL sign extension: CY ← 0, V ← 0<br>AH ≠ AL sign extension: CY ← 1, V ← 1      | U     | ×  | × | U | U | U |
|                             |          | reg16                                        | 1 1 1 1 0 1 1 1 | 1 1 1 0 1 reg   | 2     | 41-47        | 41-47           | DW, AW ← AW × reg16<br>DW = AW sign extension: CY ← 0, V ← 0<br>DW ≠ AW sign extension: CY ← 1, V ← 1   | U     | ×  | × | U | U | U |
|                             |          | mem16                                        | 1 1 1 1 0 1 1 1 | mod 1 0 1 mem   | 2-4   | 50-56        | 46-52/<br>50-56 | DW, AW ← AW × (mem16)<br>DW = AW sign extension: CY ← 0, V ← 0<br>DW ≠ AW sign extension: CY ← 1, V ← 1 | U     | ×  | × | U | U | U |
|                             |          | reg16,<br>(reg16'), <sup>Note</sup><br>imm8  | 0 1 1 0 1 0 1 1 | 1 1 reg reg'    | 3     | 28-34        | 28-34           | reg16 ← reg16' × imm8<br>Product ≤ 16 bits : CY ← 0, V ← 0<br>Product > 16 bits : CY ← 1, V ← 1         | U     | ×  | × | U | U | U |
|                             |          | reg16,<br>mem16,<br>imm8                     | 0 1 1 0 1 0 1 1 | mod reg mem     | 3-5   | 37-43        | 33-39/<br>37-43 | reg16 ← (mem16) × imm8<br>Product ≤ 16 bits : CY ← 0, V ← 0<br>Product > 16 bits : CY ← 1, V ← 1        | U     | ×  | × | U | U | U |
|                             |          | reg16,<br>(reg16'), <sup>Note</sup><br>imm16 | 0 1 1 0 1 0 0 1 | 1 1 reg reg'    | 4     | 36-42        | 36-42           | reg16 ← reg16' × imm16<br>Product ≤ 16 bits : CY ← 0, V ← 0<br>Product > 16 bits : CY ← 1, V ← 1        | U     | ×  | × | U | U | U |
|                             |          | reg16,<br>mem16,<br>imm16                    | 0 1 1 0 1 0 0 1 | mod reg mem     | 4-6   | 45-51        | 41-47/<br>45-51 | reg16 ← (mem16) × imm16<br>Product ≤ 16 bits : CY ← 0, V ← 0<br>Product > 16 bits : CY ← 1, V ← 1       | U     | ×  | × | U | U | U |

**Note** The 2nd operand can be omitted, in which case the same register as the 1st operand is taken as being specified.

| Instruction Group              | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |       | Operation                                                                                                                                                                                                                                                                                           | Flags |    |   |   |   |   |
|--------------------------------|----------|------------|-----------------|-----------------|-------|--------------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                                |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL |                                                                                                                                                                                                                                                                                                     | AC    | CY | V | P | S | Z |
| Unsigned division instructions | DIVU     | reg8       | 1 1 1 1 0 1 1 0 | 1 1 1 1 0 reg   | 2     | 19           | 19    | temp ← AW<br>If temp ÷ reg8 ≤ FFH<br>AH ← temp%reg8, AL ← temp ÷ reg8<br>If temp ÷ reg8 > FFH<br>TA ← (001H, 000H), TC ← (003H, 002H)<br>SP ← SP - 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0<br>SP ← SP - 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP - 2, (SP + 1, SP) ← PC, PC ← TA                     | U     | U  | U | U | U | U |
|                                |          | mem8       | 1 1 1 1 0 1 1 0 | mod 1 1 0 mem   | 2-4   | 24           | 24    | temp ← AW<br>If temp ÷ (mem8) ≤ FFH<br>AH ← temp%(mem8), AL ← temp ÷ (mem8)<br>If temp ÷ (mem8) > FFH<br>TA ← (001H, 000H), TC ← (003H, 002H)<br>SP ← SP - 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0<br>SP ← SP - 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP - 2, (SP + 1, SP) ← PC, PC ← TA             | U     | U  | U | U | U | U |
|                                |          | reg16      | 1 1 1 1 0 1 1 1 | 1 1 1 1 0 reg   | 2     | 25           | 25    | temp ← DW, AW<br>If temp ÷ reg16 ≤ FFFFH<br>DW ← temp%reg16, AW ← temp ÷ reg16<br>If temp ÷ reg16 > FFFFH<br>TA ← (001H, 000H), TC ← (003H, 002H)<br>SP ← SP - 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0<br>SP ← SP - 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP - 2, (SP + 1, SP) ← PC, PC ← TA         | U     | U  | U | U | U | U |
|                                |          | mem16      | 1 1 1 1 0 1 1 1 | mod 1 1 0 mem   | 2-4   | 34           | 30/34 | temp ← DW, AW<br>If temp ÷ (mem16) ≤ FFFFH<br>DW ← temp%(mem16), AW ← temp ÷ (mem16)<br>If temp ÷ (mem16) > FFFFH<br>TA ← (001H, 000H), TC ← (003H, 002H)<br>SP ← SP - 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0<br>SP ← SP - 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP - 2, (SP + 1, SP) ← PC, PC ← TA | U     | U  | U | U | U | U |

| Instruc-<br>tion<br>Group    | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |                 | Operation                                                                                                                                                                                                                                                                                                                                                                                                                                           | Flags |    |   |   |   |   |
|------------------------------|----------|------------|-----------------|-----------------|-------|--------------|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                              |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL           |                                                                                                                                                                                                                                                                                                                                                                                                                                                     | AC    | CY | V | P | S | Z |
| Signed division instructions | DIV      | reg8       | 1 1 1 1 0 1 1 0 | 1 1 1 1 1 reg   | 2     | 29-34        | 29-34           | temp ← AW<br>If temp ÷ reg8 > 0 and temp ÷ reg8 ≤ 7FH<br>or temp ÷ reg8 < 0 and temp ÷ reg8 > 0 – 7FH –1<br>AH ← temp%reg8, AL ← temp ÷ reg8<br>If temp ÷ reg8 > 0 and temp ÷ reg8 > 7FH<br>or temp ÷ reg8 < 0 and temp ÷ reg8 ≤ 0 – 7FH –1<br>TA ← (001H, 000H), TC ← (003H, 002H)<br>SP ← SP – 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0<br>SP ← SP – 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP – 2, (SP + 1, SP) ← PC, PC ← TA                       | U     | U  | U | U | U | U |
|                              |          | mem8       | 1 1 1 1 0 1 1 0 | mod 1 1 1 mem   | 2-4   | 34-39        | 34-39           | temp ← AW<br>If temp ÷ (mem8) > 0 and temp ÷ (mem8) ≤ 7FH<br>or temp ÷ (mem8) < 0 and temp ÷ (mem8) > 0 – 7FH –1<br>AH ← temp%(mem8), AL ← temp ÷ (mem8)<br>If temp ÷ (mem8) > 0 and temp ÷ (mem8) > 7FH<br>or temp ÷ (mem8) < 0 and temp ÷ (mem8) ≤ 0 – 7FH –1<br>TA ← (001H, 000H), TC ← (003H, 002H)<br>SP ← SP – 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0<br>SP ← SP – 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP – 2, (SP + 1, SP) ← PC, PC ← TA   | U     | U  | U | U | U | U |
|                              |          | reg16      | 1 1 1 1 0 1 1 1 | 1 1 1 1 1 reg   | 2     | 38-43        | 38-43           | temp ← DW, AW<br>If temp ÷ reg16 > 0 and temp ÷ reg16 ≤ 7FFFH<br>or temp ÷ reg16 < 0 and temp ÷ reg16 > 0 – 7FFFH –1<br>DW ← temp%reg16, AW ← temp ÷ reg16<br>If temp ÷ reg16 > 0 and temp ÷ reg16 > 7FFFH<br>or temp ÷ reg16 < 0 and temp ÷ reg16 ≤ 0 – 7FFFH –1<br>TA ← (001H, 000H), TC ← (003H, 002H)<br>SP ← SP – 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0<br>SP ← SP – 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP – 2, (SP + 1, SP) ← PC, PC ← TA | U     | U  | U | U | U | U |
|                              |          | mem16      | 1 1 1 1 0 1 1 1 | mod 1 1 1 mem   | 2-4   | 47-52        | 43-48/<br>47-52 | temp ← DW, AW<br>If temp ÷ (mem16) > 0 and temp ÷ (mem16) ≤ 7FFFH<br>or temp ÷ (mem16) < 0 and temp ÷ (mem16) > 0 – 7FFFH –1<br>DW ← temp%(mem16), AW ← temp ÷ (mem16)<br>If temp ÷ (mem16) > 0 and temp ÷ (mem16) > 7FFFH<br>or temp ÷ (mem16) < 0 and temp ÷ (mem16) ≤ 0 – 7FFFH –1<br>TA ← (001H, 000H), TC ← (003H, 002H)<br>SP ← SP – 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0                                                                   | U     | U  | U | U | U | U |

| Instruction Group                 | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |       | Operation                                                                                                                                                                                  | Flags |    |   |   |   |   |
|-----------------------------------|----------|------------|-----------------|-----------------|-------|--------------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                                   |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL |                                                                                                                                                                                            | AC    | CY | V | P | S | Z |
| BCD adjustment instructions       | ADJBA    |            | 0 0 1 1 0 1 1 1 |                 | 1     | 7            | 7     | If $AL \wedge 0FH > 9$ or $AC = 1$ : $AL \leftarrow AL + 6$<br>$AH \leftarrow AH + 1$ , $AC \leftarrow 1$ , $CY \leftarrow AC$ , $AL \leftarrow AL \wedge 0FH$                             | ×     | ×  | U | U | U | U |
|                                   | ADJ4A    |            | 0 0 1 0 0 1 1 1 |                 | 1     | 3            | 3     | If $AL \wedge 0FH > 9$ or $AC = 1$<br>$AL \leftarrow AL + 6$ , $CY \leftarrow CY \vee AC$ , $AC \leftarrow 1$<br>If $AL > 9FH$ or $CY = 1$<br>$AL \leftarrow AL + 60H$ , $CY \leftarrow 1$ | ×     | ×  | U | × | × | × |
|                                   | ADJBS    |            | 0 0 1 1 1 1 1 1 |                 | 1     | 7            | 7     | If $AL \wedge 0FH > 9$ or $AC = 1$<br>$AL \leftarrow AL - 6$ , $AH \leftarrow AH - 1$ , $AC \leftarrow 1$<br>$CY \leftarrow AC$ , $AL \leftarrow AL \wedge 0FH$                            | ×     | ×  | U | U | U | U |
|                                   | ADJ4S    |            | 0 0 1 0 1 1 1 1 |                 | 1     | 3            | 3     | If $AL \wedge 0FH > 9$ or $AC = 1$<br>$AL \leftarrow AL - 6$ , $CY \leftarrow CY \vee AC$ , $AC \leftarrow 1$<br>If $AL > 9FH$ or $CY = 1$<br>$AL \leftarrow AL - 60H$ , $CY \leftarrow 1$ | ×     | ×  | U | × | × | × |
| Data conversion instructions      | CVTBD    |            | 1 1 0 1 0 1 0 0 | 0 0 0 0 1 0 1 0 | 2     | 15           | 15    | $AH \leftarrow AL \div 0AH$ , $AL \leftarrow AL \% 0AH$                                                                                                                                    | U     | U  | U | × | × | × |
|                                   | CVTDB    |            | 1 1 0 1 0 1 0 1 | 0 0 0 0 1 0 1 0 | 2     | 7            | 7     | $AL \leftarrow AH \times 0AH + AL$ , $AH \leftarrow 0$                                                                                                                                     | U     | U  | U | × | × | × |
|                                   | CVTBW    |            | 1 0 0 1 1 0 0 0 |                 | 1     | 2            | 2     | If $AL < 80H$ : $AH \leftarrow 0$ , otherwise: $AH \leftarrow FFH$                                                                                                                         |       |    |   |   |   |   |
|                                   | CVTWL    |            | 1 0 0 1 1 0 0 1 |                 | 1     | 4-5          | 4-5   | If $AW < 8000H$ : $DW \leftarrow 0$ , otherwise: $DW \leftarrow FFFFH$                                                                                                                     |       |    |   |   |   |   |
| Comparison instructions           | CMP      | reg, reg'  | 0 0 1 1 1 0 1 W | 1 1 reg reg'    | 2     | 2            | 2     | $reg - reg'$                                                                                                                                                                               | ×     | ×  | × | × | × | × |
|                                   |          | mem, reg   | 0 0 1 1 1 0 0 W | mod reg mem     | 2-4   | 10/14        | 10/14 | $(mem) - reg$                                                                                                                                                                              | ×     | ×  | × | × | × | × |
|                                   |          | reg, mem   | 0 0 1 1 1 0 1 W | mod reg mem     | 2-4   | 10/14        | 10/14 | $reg - (mem)$                                                                                                                                                                              | ×     | ×  | × | × | × | × |
|                                   |          | reg, imm   | 1 0 0 0 0 0 s W | 1 1 1 1 1 reg   | 3-4   | 4            | 4     | $reg - imm$                                                                                                                                                                                | ×     | ×  | × | × | × | × |
|                                   |          | mem, imm   | 1 0 0 0 0 0 s W | mod 1 1 1 mem   | 3-6   | 12/16        | 12/16 | $(mem) - imm$                                                                                                                                                                              | ×     | ×  | × | × | × | × |
|                                   |          | acc, imm   | 0 0 1 1 1 1 0 W |                 | 2-3   | 4            | 4     | If $W = 0$ : $AL - imm$<br>If $W = 1$ : $AW - imm$                                                                                                                                         | ×     | ×  | × | × | × | × |
| Complement operation instructions | NOT      | reg        | 1 1 1 1 0 1 1 W | 1 1 0 1 0 reg   | 2     | 2            | 2     | $reg \leftarrow \overline{reg}$                                                                                                                                                            |       |    |   |   |   |   |
|                                   |          | mem        | 1 1 1 1 0 1 1 W | mod 0 1 0 mem   | 2-4   | 13/21        | 13/21 | $(mem) \leftarrow \overline{(mem)}$                                                                                                                                                        |       |    |   |   |   |   |
|                                   | NEG      | reg        | 1 1 1 1 0 1 1 W | 1 1 0 1 1 reg   | 2     | 2            | 2     | $reg \leftarrow \overline{reg} + 1$                                                                                                                                                        | ×     | ×  | × | × | × | × |
|                                   |          | mem        | 1 1 1 1 0 1 1 W | mod 0 1 mem     | 2-4   | 13/21        | 13/21 | $(mem) \leftarrow \overline{(mem)} + 1$                                                                                                                                                    | ×     | ×  | × | × | × | × |

| Instruction Group              | Mnemonic | Operand(s)           | Operation Code  |                 | Bytes | Clock Cycles |       | Operation                                                                                 | Flags |    |   |   |   |   |
|--------------------------------|----------|----------------------|-----------------|-----------------|-------|--------------|-------|-------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                                |          |                      | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL |                                                                                           | AC    | CY | V | P | S | Z |
| Logical operation instructions | TEST     | reg, reg'            | 1 0 0 0 0 1 0 W | 1 1 reg' reg    | 2     | 2            | 2     | reg $\wedge$ reg'                                                                         | U     | 0  | 0 | x | x | x |
|                                |          | mem, reg<br>reg, mem | 1 0 0 0 0 1 0 W | mod reg mem     | 2-4   | 9/13         | 9/13  | (mem) $\wedge$ reg                                                                        | U     | 0  | 0 | x | x | x |
|                                |          | reg, imm             | 1 1 1 1 0 1 1 W | 1 1 0 0 0 reg   | 3-4   | 4            | 4     | reg $\wedge$ imm                                                                          | U     | 0  | 0 | x | x | x |
|                                |          | mem, imm             | 1 1 1 1 0 1 1 W | mod 0 0 0 mem   | 3-6   | 10/14        | 10/14 | (mem) $\wedge$ imm                                                                        | U     | 0  | 0 | x | x | x |
|                                |          | acc, imm             | 1 0 1 0 1 0 0 W |                 | 2-3   | 4            | 4     | If W = 0: AL $\wedge$ imm8<br>If W = 1: AW $\wedge$ imm16                                 | U     | 0  | 0 | x | x | x |
|                                | AND      | reg, reg'            | 0 0 1 0 0 0 1 W | 1 1 reg reg'    | 2     | 2            | 2     | reg $\leftarrow$ reg $\wedge$ reg'                                                        | U     | 0  | 0 | x | x | x |
|                                |          | mem, reg             | 0 0 1 0 0 0 0 W | mod reg mem     | 2-4   | 13/21        | 13/21 | (mem) $\leftarrow$ (mem) $\wedge$ reg                                                     | U     | 0  | 0 | x | x | x |
|                                |          | reg, mem             | 0 0 1 0 0 0 1 W | mod reg mem     | 2-4   | 10/14        | 10/14 | reg $\leftarrow$ reg $\wedge$ (mem)                                                       | U     | 0  | 0 | x | x | x |
|                                |          | reg, imm             | 1 0 0 0 0 0 0 W | 1 1 1 0 0 reg   | 3-4   | 4            | 4     | reg $\leftarrow$ reg $\wedge$ imm                                                         | U     | 0  | 0 | x | x | x |
|                                |          | mem, imm             | 1 0 0 0 0 0 0 W | mod 1 0 0 mem   | 3-6   | 15/23        | 15/23 | (mem) $\leftarrow$ (mem) $\wedge$ imm                                                     | U     | 0  | 0 | x | x | x |
|                                |          | acc, imm             | 0 0 1 0 0 1 0 W |                 | 2-3   | 4            | 4     | If W = 0: AL $\leftarrow$ AL $\wedge$ imm8<br>If W = 1: AW $\leftarrow$ AW $\wedge$ imm16 | U     | 0  | 0 | x | x | x |
|                                | OR       | reg, reg'            | 0 0 0 0 1 0 1 W | 1 1 reg reg'    | 2     | 2            | 2     | reg $\leftarrow$ reg $\vee$ reg'                                                          | U     | 0  | 0 | x | x | x |
|                                |          | mem, reg             | 0 0 0 0 1 0 0 W | mod reg mem     | 2-4   | 13/21        | 13/21 | (mem) $\leftarrow$ (mem) $\vee$ reg                                                       | U     | 0  | 0 | x | x | x |
|                                |          | reg, mem             | 0 0 0 0 1 0 1 W | mod reg mem     | 2-4   | 10/14        | 10/14 | reg $\leftarrow$ reg $\vee$ (mem)                                                         | U     | 0  | 0 | x | x | x |
|                                |          | reg, imm             | 1 0 0 0 0 0 0 W | 1 1 0 0 1 reg   | 3-4   | 4            | 4     | reg $\leftarrow$ reg $\vee$ imm                                                           | U     | 0  | 0 | x | x | x |
|                                |          | mem, imm             | 1 0 0 0 0 0 0 W | mod 0 0 1 mem   | 3-6   | 15/23        | 15/23 | (mem) $\leftarrow$ (mem) $\vee$ imm                                                       | U     | 0  | 0 | x | x | x |
|                                |          | acc, imm             | 0 0 0 0 1 1 0 W |                 | 2-3   | 4            | 4     | If W = 0: AL $\leftarrow$ AL $\vee$ imm8<br>If W = 1: AW $\leftarrow$ AW $\vee$ imm16     | U     | 0  | 0 | x | x | x |
|                                | XOR      | reg, reg'            | 0 0 1 1 0 0 1 W | 1 1 reg reg'    | 2     | 2            | 2     | reg $\leftarrow$ reg $\nabla$ reg'                                                        | U     | 0  | 0 | x | x | x |
|                                |          | mem, reg             | 0 0 1 1 0 0 0 W | mod reg mem     | 2-4   | 13/21        | 13/21 | (mem) $\leftarrow$ (mem) $\nabla$ reg                                                     | U     | 0  | 0 | x | x | x |
|                                |          | reg, mem             | 0 0 1 1 0 0 1 W | mod reg mem     | 2-4   | 10/14        | 10/14 | reg $\leftarrow$ reg $\nabla$ (mem)                                                       | U     | 0  | 0 | x | x | x |
|                                |          | reg, imm             | 1 0 0 0 0 0 0 W | 1 1 1 1 0 reg   | 3-4   | 4            | 4     | reg $\leftarrow$ reg $\nabla$ imm                                                         | U     | 0  | 0 | x | x | x |
|                                |          | mem, imm             | 1 0 0 0 0 0 0 W | mod 1 1 0 mem   | 3-6   | 15/23        | 15/23 | (mem) $\leftarrow$ (mem) $\nabla$ imm                                                     | U     | 0  | 0 | x | x | x |
|                                |          | acc, imm             | 0 0 1 1 0 1 0 W |                 | 2-3   | 4            | 4     | If W = 0: AL $\leftarrow$ AL $\nabla$ imm8<br>If W = 1: AW $\leftarrow$ AW $\nabla$ imm16 | U     | 0  | 0 | x | x | x |

| Instruction Group             | Mnemonic | Operand(s)  | Operation Code  |                 | Bytes | Clock Cycles |       | Operation                                                                                | Flags |    |   |   |   |   |
|-------------------------------|----------|-------------|-----------------|-----------------|-------|--------------|-------|------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                               |          |             | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL |                                                                                          | AC    | CY | V | P | S | Z |
| Bit manipulation instructions | TEST1    | reg8, CL    | 0 0 0 1 0 0 0 0 | 1 1 0 0 0 reg   | 3     | 3            | 3     | reg8 bit NO.CL = 0 : $Z \leftarrow 1$<br>reg8 bit NO.CL = 1 : $Z \leftarrow 0$           | U     | 0  | 0 | U | U | × |
|                               |          | mem8, CL    | 0 0 0 0         | mod 0 0 0 mem   | 3-5   | 7            | 7     | (mem8) bit NO.CL = 0 : $Z \leftarrow 1$<br>(mem8) bit NO.CL = 1 : $Z \leftarrow 0$       | U     | 0  | 0 | U | U | × |
|                               |          | reg16, CL   | 0 0 0 1         | 1 1 0 0 0 mem   | 3     | 3            | 3     | reg16 bit NO.CL = 0 : $Z \leftarrow 1$<br>reg16 bit NO.CL = 1 : $Z \leftarrow 0$         | U     | 0  | 0 | U | U | × |
|                               |          | mem16, CL   | 0 0 0 1         | mod 0 0 0 mem   | 3-5   | 11           | 7/11  | (mem16) bit NO.CL = 0 : $Z \leftarrow 1$<br>(mem16) bit NO.CL = 1 : $Z \leftarrow 0$     | U     | 0  | 0 | U | U | × |
|                               |          | reg8, imm3  | 1 0 0 0         | 1 1 0 0 0 reg   | 4     | 4            | 4     | reg8 bit NO.imm3 = 0 : $Z \leftarrow 1$<br>reg8 bit NO.imm3 = 1 : $Z \leftarrow 0$       | U     | 0  | 0 | U | U | × |
|                               |          | mem8, imm3  | 1 0 0 0         | mod 0 0 0 mem   | 4-6   | 8            | 8     | (mem8) bit NO.imm3 = 0 : $Z \leftarrow 1$<br>(mem8) bit NO.imm3 = 1 : $Z \leftarrow 0$   | U     | 0  | 0 | U | U | × |
|                               |          | reg16, imm4 | 1 0 0 1         | 1 1 0 0 0 reg   | 4     | 4            | 4     | reg16 bit NO.imm4 = 0 : $Z \leftarrow 1$<br>reg16 bit NO.imm4 = 1 : $Z \leftarrow 0$     | U     | 0  | 0 | U | U | × |
|                               |          | mem16, imm4 | 1 0 0 1         | mod 0 0 0 mem   | 4-6   | 12           | 8/12  | (mem16) bit NO.imm4 = 0 : $Z \leftarrow 1$<br>(mem16) bit NO.imm4 = 1 : $Z \leftarrow 0$ | U     | 0  | 0 | U | U | × |
|                               | NOT1     | reg8, CL    | 0 1 1 0         | 1 1 0 0 0 reg   | 3     | 4            | 4     | reg8 bit NO.CL ← $\overline{\text{reg8 bit NO.CL}}$                                      |       |    |   |   |   |   |
|                               |          | mem8, CL    | 0 1 1 0         | mod 0 0 0 mem   | 3-5   | 10           | 10    | (mem8) bit NO.CL ← $\overline{(\text{mem8}) \text{ bit NO.CL}}$                          |       |    |   |   |   |   |
|                               |          | reg16, CL   | 0 1 1 1         | 1 1 0 0 0 reg   | 3     | 4            | 4     | reg16 bit NO.CL ← $\overline{\text{reg16 bit NO.CL}}$                                    |       |    |   |   |   |   |
|                               |          | mem16, CL   | 0 1 1 1         | mod 0 0 0 mem   | 3-5   | 18           | 10/18 | (mem16) bit NO.CL ← $\overline{(\text{mem16}) \text{ bit NO.CL}}$                        |       |    |   |   |   |   |
|                               |          | reg8, imm3  | 1 1 1 0         | 1 1 0 0 0 reg   | 4     | 5            | 5     | reg8 bit NO.imm3 ← $\overline{\text{reg8 bit NO.imm3}}$                                  |       |    |   |   |   |   |
|                               |          | mem8, imm3  | 1 1 1 0         | mod 0 0 0 mem   | 4-6   | 11           | 11    | (mem8) bit NO.imm3 ← $\overline{(\text{mem8}) \text{ bit NO.imm3}}$                      |       |    |   |   |   |   |
|                               |          | reg16, imm4 | 1 1 1 1         | 1 1 0 0 0 reg   | 4     | 5            | 5     | reg16 bit NO.imm4 ← $\overline{\text{reg16 bit NO.imm4}}$                                |       |    |   |   |   |   |
|                               |          | mem16, imm4 | 1 1 1 1         | mod 0 0 0 mem   | 4-6   | 19           | 11/19 | (mem16) bit NO.imm4 ← $\overline{(\text{mem16}) \text{ bit NO.imm4}}$                    |       |    |   |   |   |   |

2nd byte\*

3rd byte\*

\* 1st byte = 0FH

|      |    |                 |   |   |   |                               |  |   |  |  |  |  |  |
|------|----|-----------------|---|---|---|-------------------------------|--|---|--|--|--|--|--|
| NOT1 | CY | 1 1 1 1 0 1 0 1 | 1 | 2 | 2 | $CY \leftarrow \overline{CY}$ |  | × |  |  |  |  |  |
|------|----|-----------------|---|---|---|-------------------------------|--|---|--|--|--|--|--|

| Instruc-<br>tion<br>Group     | Mnemonic | Operand(s)  | Operation Code  |                 | Bytes | Clock Cycles |       | Operation               | Flags |    |   |   |   |   |
|-------------------------------|----------|-------------|-----------------|-----------------|-------|--------------|-------|-------------------------|-------|----|---|---|---|---|
|                               |          |             | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL |                         | AC    | CY | V | P | S | Z |
| Bit manipulation instructions | CLR1     | reg8, CL    | 0 0 0 1 0 0 1 0 | 1 1 0 0 0 reg   | 3     | 5            | 5     | reg8 bit NO.CL ← 0      |       |    |   |   |   |   |
|                               |          | mem8, CL    | 0 0 1 0         | mod 0 0 0 mem   | 3-5   | 11           | 11    | (mem8) bit NO.CL ← 0    |       |    |   |   |   |   |
|                               |          | reg16, CL   | 0 0 1 1         | 1 1 0 0 0 mem   | 3     | 5            | 5     | reg16 bit NO.CL ← 0     |       |    |   |   |   |   |
|                               |          | mem16, CL   | 0 0 1 1         | mod 0 0 0 mem   | 3-5   | 19           | 11/19 | (mem16) bit NO.CL ← 0   |       |    |   |   |   |   |
|                               |          | reg8, imm3  | 1 0 1 0         | 1 1 0 0 0 reg   | 4     | 6            | 6     | reg8 bit NO.imm3 ← 0    |       |    |   |   |   |   |
|                               |          | mem8, imm3  | 1 0 1 0         | mod 0 0 0 mem   | 4-6   | 12           | 12    | (mem8) bit NO.imm3 ← 0  |       |    |   |   |   |   |
|                               |          | reg16, imm4 | 1 0 1 1         | 1 1 0 0 0 reg   | 4     | 6            | 6     | reg16 bit NO.imm4 ← 0   |       |    |   |   |   |   |
|                               |          | mem16, imm4 | 1 0 1 1         | mod 0 0 0 mem   | 4-6   | 20           | 12/20 | (mem16) bit NO.imm4 ← 0 |       |    |   |   |   |   |
|                               | SET1     | reg8, CL    | 0 1 0 0         | 1 1 0 0 0 reg   | 3     | 4            | 4     | reg8 bit NO.CL ← 1      |       |    |   |   |   |   |
|                               |          | mem8, CL    | 0 1 0 0         | mod 0 0 0 mem   | 3-5   | 10           | 10    | (mem8) bit NO.CL ← 1    |       |    |   |   |   |   |
|                               |          | reg16, CL   | 0 1 0 1         | 1 1 0 0 0 reg   | 3     | 4            | 4     | reg16 bit NO.CL ← 1     |       |    |   |   |   |   |
|                               |          | mem16, CL   | 0 1 0 1         | mod 0 0 0 mem   | 3-5   | 18           | 10/18 | (mem16) bit NO.CL ← 1   |       |    |   |   |   |   |
|                               |          | reg8, imm3  | 1 1 0 0         | 1 1 0 0 0 reg   | 4     | 5            | 5     | reg8 bit NO.imm3 ← 1    |       |    |   |   |   |   |
|                               |          | mem8, imm3  | 1 1 0 0         | mod 0 0 0 mem   | 4-6   | 11           | 11    | (mem8) bit NO.imm3 ← 1  |       |    |   |   |   |   |
|                               |          | reg16, imm4 | 1 1 0 1         | 1 1 0 0 0 reg   | 4     | 5            | 5     | reg16 bit NO.imm4 ← 1   |       |    |   |   |   |   |
|                               |          | mem16, imm4 | 1 1 0 1         | mod 0 0 0 mem   | 4-6   | 19           | 11/19 | (mem16) bit NO.imm4 ← 1 |       |    |   |   |   |   |

2nd byte\*      3rd byte\*      \* 1st byte = 0FH

|  |      |     |                 |  |   |   |   |         |  |   |  |  |  |  |
|--|------|-----|-----------------|--|---|---|---|---------|--|---|--|--|--|--|
|  | CLR1 | CY  | 1 1 1 1 1 0 0 0 |  | 1 | 2 | 2 | CY ← 0  |  | 0 |  |  |  |  |
|  |      | DIR | 1 1 1 1 1 1 0 0 |  | 1 | 2 | 2 | DIR ← 0 |  |   |  |  |  |  |
|  | SET1 | CY  | 1 1 1 1 1 0 0 1 |  | 1 | 2 | 2 | CY ← 1  |  | 1 |  |  |  |  |
|  |      | DIR | 1 1 1 1 1 1 0 1 |  | 1 | 2 | 2 | DIR ← 1 |  |   |  |  |  |  |

| Instruction Group  | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |           | Operation                                                                                                                  | Flags |    |   |   |   |   |
|--------------------|----------|------------|-----------------|-----------------|-------|--------------|-----------|----------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                    |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL     |                                                                                                                            | AC    | CY | V | P | S | Z |
| Shift instructions | SHL      | reg, 1     | 1 1 0 1 0 0 0 W | 1 1 1 0 0 reg   | 2     | 6            | 6         | CY ← reg MSB, reg ← reg × 2<br>If reg MSB ≠ CY: V ← 1<br>If reg MSB = CY: V ← 0                                            | U     | ×  | × | × | × | × |
|                    |          | mem, 1     | 1 1 0 1 0 0 0 W | mod 1 0 0 mem   | 2-4   | 13/21        | 13/21     | CY ← (mem) MSB, (mem) ← (mem) × 2<br>If (mem) MSB ≠ CY: V ← 1<br>If (mem) MSB = CY: V ← 0                                  | U     | ×  | × | × | × | × |
|                    |          | reg, CL    | 1 1 0 1 0 0 1 W | 1 1 1 0 0 reg   | 2     | 7 + n        | 7 + n     | temp ← CL, while temp ≠ 0 the following operation are repeated:<br>CY ← reg MSB, reg ← reg × 2<br>temp ← temp – 1          | U     | ×  | U | × | × | × |
|                    |          | mem, CL    | 1 1 0 1 0 0 1 W | mod 1 0 0 mem   | 2-4   | 16/24 + n    | 16/24 + n | temp ← CL, while temp ≠ 0 the following operation are repeated:<br>CY ← (mem) MSB, (mem) ← (mem) × 2<br>temp ← temp – 1    | U     | ×  | U | × | × | × |
|                    |          | reg, imm8  | 1 1 0 0 0 0 0 W | 1 1 1 0 0 reg   | 3     | 7 + n        | 7 + n     | temp ← imm8, while temp ≠ 0 the following operations are repeated:<br>CY ← reg MSB, reg ← reg × 2<br>temp ← temp – 1       | U     | ×  | U | × | × | × |
|                    |          | mem, imm8  | 1 1 0 0 0 0 0 W | mod 1 0 0 mem   | 3-5   | 16/24 + n    | 16/24 + n | temp ← imm8, while temp ≠ 0 the following operations are repeated:<br>CY ← (mem) MSB, (mem) ← (mem) × 2<br>temp ← temp – 1 | U     | ×  | U | × | × | × |

n: Number of shifts

| Instruction Group  | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |           | Operation                                                                                                                     | Flags |    |   |   |   |   |
|--------------------|----------|------------|-----------------|-----------------|-------|--------------|-----------|-------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                    |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL     |                                                                                                                               | AC    | CY | V | P | S | Z |
| Shift instructions | SHR      | reg, 1     | 1 1 0 1 0 0 0 W | 1 1 1 0 1 reg   | 2     | 6            | 6         | CY ← reg LSB, reg ← reg ÷ 2<br>If reg MSB ≠ bit after reg MSB : V ← 1<br>If reg MSB = bit after reg MSB : V ← 0               | U     | ×  | × | × | × | × |
|                    |          | mem, 1     | 1 1 0 1 0 0 0 W | mod 1 0 1 mem   | 2-4   | 13/21        | 13/21     | CY ← (mem) LSB, (mem) ← (mem) ÷ 2<br>If (mem) MSB ≠ bit after (mem) MSB : V ← 1<br>If (mem) MSB = bit after (mem) MSB : V ← 0 | U     | ×  | × | × | × | × |
|                    |          | reg, CL    | 1 1 0 1 0 0 1 W | 1 1 1 0 1 reg   | 2     | 7 + n        | 7 + n     | temp ← CL, while temp ≠ 0 the following operations are repeated:<br>CY ← reg LSB, reg ← reg ÷ 2<br>temp ← temp – 1            | U     | ×  | U | × | × | × |
|                    |          | mem, CL    | 1 1 0 1 0 0 1 W | mod 1 0 1 mem   | 2-4   | 16/24 + n    | 16/24 + n | temp ← CL, while temp ≠ 0 the following operations are repeated:<br>CY ← (mem) LSB, (mem) ← (mem) ÷ 2<br>temp ← temp – 1      | U     | ×  | U | × | × | × |
|                    |          | reg, imm8  | 1 1 0 0 0 0 0 W | 1 1 1 0 1 reg   | 3     | 7 + n        | 7 + n     | temp ← imm8, while temp ≠ 0 the following operations are repeated:<br>CY ← reg LSB, reg ← reg ÷ 2<br>temp ← temp – 1          | U     | ×  | U | × | × | × |
|                    |          | mem, imm8  | 1 1 0 0 0 0 0 W | mod 1 0 1 mem   | 3-5   | 16/24 + n    | 16/24 + n | temp ← imm8, while temp ≠ 0 the following operations are repeated:<br>CY ← (mem) LSB, (mem) ← (mem) ÷ 2<br>temp ← temp – 1    | U     | ×  | U | × | × | × |

n: Number of shifts

| Instruc-<br>tion<br>Group | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |              | Operation                                                                                                                                                | Flags |    |   |   |   |   |
|---------------------------|----------|------------|-----------------|-----------------|-------|--------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                           |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL        |                                                                                                                                                          | AC    | CY | V | P | S | Z |
|                           | SHRA     | reg, 1     | 1 1 0 1 0 0 0 W | 1 1 1 1 1 reg   | 2     | 6            | 6            | CY ← reg LSB, reg ← reg ÷ 2, V ← 0<br>MSB of operand is unchanged.                                                                                       | U     | ×  | 0 | × | × | × |
|                           |          | mem, 1     | 1 1 0 1 0 0 0 W | mod 1 1 1 mem   | 2-4   | 13/21        | 13/21        | CY ← (mem) LSB, (mem) ← (mem) ÷ 2, V ← 0<br>MSB of operand is unchanged.                                                                                 | U     | ×  | 0 | × | × | × |
|                           |          | reg, CL    | 1 1 0 1 0 0 1 W | 1 1 1 1 1 reg   | 2     | 7 + n        | 7 + n        | temp ← CL, while temp ≠ 0 the following operations are repeated:<br>CY ← reg LSB, reg ← reg ÷ 2<br>temp ← temp – 1, MSB of operand is unchanged.         | U     | ×  | U | × | × | × |
|                           |          | mem, CL    | 1 1 0 1 0 0 1 W | mod 1 1 1 mem   | 2-4   | 16/24<br>+ n | 16/24<br>+ n | temp ← CL, while temp ≠ 0 the following operations are repeated:<br>CY ← (mem) LSB, (mem) ← (mem) ÷ 2<br>temp ← temp – 1, MSB of operand is unchanged.   | U     | ×  | U | × | × | × |
|                           |          | reg, imm8  | 1 1 0 0 0 0 0 W | 1 1 1 1 1 reg   | 3     | 7 + n        | 7 + n        | temp ← imm8, while temp ≠ 0 the following operations are repeated:<br>CY ← reg LSB, reg ← reg ÷ 2<br>temp ← temp – 1, MSB of operand is unchanged.       | U     | ×  | U | × | × | × |
|                           |          | mem, imm8  | 1 1 0 0 0 0 0 W | mod 1 1 1 mem   | 3-5   | 16/24<br>+ n | 16/24<br>+ n | temp ← imm8, while temp ≠ 0 the following operations are repeated:<br>CY ← (mem) LSB, (mem) ← (mem) ÷ 2<br>temp ← temp – 1, MSB of operand is unchanged. | U     | ×  | U | × | × | × |

n: Number of shifts

| Instruction Group   | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |           | Operation                                                                                                                       | Flags |    |   |   |   |   |
|---------------------|----------|------------|-----------------|-----------------|-------|--------------|-----------|---------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                     |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL     |                                                                                                                                 | AC    | CY | V | P | S | Z |
| Rotate instructions | ROL      | reg, 1     | 1 1 0 1 0 0 0 W | 1 1 0 0 0 reg   | 2     | 6            | 6         | CY ← reg MSB, reg ← reg × 2 + CY<br>reg MSB ≠ CY : V ← 1<br>reg MSB = CY : V ← 0                                                |       | ×  | × |   |   |   |
|                     |          | mem, 1     | 1 1 0 1 0 0 0 W | mod 0 0 0 mem   | 2-4   | 13/21        | 13/21     | CY ← (mem) MSB, (mem) ← (mem) × 2 + CY<br>(mem) MSB ≠ CY : V ← 1<br>(mem) MSB = CY : V ← 0                                      |       | ×  | × |   |   |   |
|                     |          | reg, CL    | 1 1 0 1 0 0 1 W | 1 1 0 0 0 reg   | 2     | 7 + n        | 7 + n     | temp ← CL, while temp ≠ 0 the following operations are repeated:<br>CY ← reg MSB, reg ← reg × 2 + CY<br>temp ← temp – 1         |       | ×  | U |   |   |   |
|                     |          | mem, CL    | 1 1 0 1 0 0 1 W | mod 0 0 0 mem   | 2-4   | 16/24 + n    | 16/24 + n | temp ← CL, while temp ≠ 0 the following operations are repeated:<br>CY ← (mem) MSB, (mem) ← (mem) × 2 + CY<br>temp ← temp – 1   |       | ×  | U |   |   |   |
|                     |          | reg, imm8  | 1 1 0 0 0 0 0 W | 1 1 0 0 0 reg   | 3     | 7 + n        | 7 + n     | temp ← imm8, while temp ≠ 0 the following operations are repeated:<br>CY ← reg MSB, reg ← reg × 2 + CY<br>temp ← temp – 1       |       | ×  | U |   |   |   |
|                     |          | mem, imm8  | 1 1 0 0 0 0 0 W | mod 0 0 0 mem   | 3-5   | 16/24 + n    | 16/24 + n | temp ← imm8, while temp ≠ 0 the following operations are repeated:<br>CY ← (mem) MSB, (mem) ← (mem) × 2 + CY<br>temp ← temp – 1 |       | ×  | U |   |   |   |

n: Number of shifts

| Instruction Group   | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |           | Operation                                                                                                                                  | Flags |    |   |   |   |   |
|---------------------|----------|------------|-----------------|-----------------|-------|--------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                     |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL     |                                                                                                                                            | AC    | CY | V | P | S | Z |
| Rotate instructions | ROR      | reg, 1     | 1 1 0 1 0 0 0 W | 1 1 0 0 1 reg   | 2     | 6            | 6         | CY ← reg LSB, reg ← reg ÷ 2<br>reg MSB ← CY<br>reg MSB ≠ bit after reg MSB : V ← 1<br>reg MSB = bit after reg MSB : V ← 0                  |       | ×  | × |   |   |   |
|                     |          | mem, 1     | 1 1 0 1 0 0 0 W | mod 0 0 1 mem   | 2-4   | 13/21        | 13/21     | CY ← (mem) LSB, (mem) ← (mem) ÷ 2<br>(mem) MSB ← CY<br>(mem) MSB ≠ bit after (mem) MSB : V ← 1<br>(mem) MSB = bit after (mem) MSB : V ← 0  |       | ×  | × |   |   |   |
|                     |          | reg, CL    | 1 1 0 1 0 0 1 W | 1 1 0 0 1 reg   | 2     | 7 + n        | 7 + n     | temp ← CL, while CL ≠ 0 the following operations are repeated:<br>CY ← reg LSB, reg ← reg ÷ 2<br>reg MSB ← CY<br>temp ← temp – 1           |       | ×  | U |   |   |   |
|                     |          | mem, CL    | 1 1 0 1 0 0 1 W | mod 0 0 1 mem   | 2-4   | 16/24 + n    | 16/24 + n | temp ← CL, while CL ≠ 0 the following operations are repeated:<br>CY ← (mem) LSB, (mem) ← (mem) ÷ 2<br>(mem) MSB ← CY<br>temp ← temp – 1   |       | ×  | U |   |   |   |
|                     |          | reg, imm8  | 1 1 0 0 0 0 0 W | 1 1 0 0 1 reg   | 3     | 7 + n        | 7 + n     | temp ← imm8, while CL ≠ 0 the following operations are repeated:<br>CY ← reg LSB, reg ← reg ÷ 2<br>reg MSB ← CY<br>temp ← temp – 1         |       | ×  | U |   |   |   |
|                     |          | mem, imm8  | 1 1 0 0 0 0 0 W | mod 0 0 1 mem   | 3-5   | 16/24 + n    | 16/24 + n | temp ← imm8, while CL ≠ 0 the following operations are repeated:<br>CY ← (mem) LSB, (mem) ← (mem) ÷ 2<br>(mem) MSB ← CY<br>temp ← temp – 1 |       | ×  | U |   |   |   |

n: Number of shifts

| Instruction Group   | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |           | Operation                                                                                                                                      | Flags |    |   |   |   |   |
|---------------------|----------|------------|-----------------|-----------------|-------|--------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                     |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL     |                                                                                                                                                | AC    | CY | V | P | S | Z |
| Rotate instructions | ROL      | reg, 1     | 1 1 0 1 0 0 0 W | 1 1 0 1 0 reg   | 2     | 6            | 6         | tmpcy ← CY, CY ← reg MSB<br>reg ← reg × 2 + tmpcy<br>reg MSB ≠ CY : V ← 1<br>reg MSB = CY : V ← 0                                              |       | ×  | × |   |   |   |
|                     |          | mem, 1     | 1 1 0 1 0 0 0 W | mod 0 1 0 mem   | 2-4   | 13/21        | 13/21     | tmpcy ← CY, CY ← (mem) MSB<br>(mem) ← (mem) × 2 + tmpcy<br>(mem) MSB ≠ CY : V ← 1<br>(mem) MSB = CY : V ← 0                                    |       | ×  | × |   |   |   |
|                     |          | reg, CL    | 1 1 0 1 0 0 1 W | 1 1 0 1 0 reg   | 2     | 7 + n        | 7 + n     | temp ← CL, while CL ≠ 0 the following operations are repeated:<br>tmpcy ← CY, CY ← reg MSB<br>reg ← reg × 2 + tmpcy<br>temp ← temp – 1         |       | ×  | U |   |   |   |
|                     |          | mem, CL    | 1 1 0 1 0 0 1 W | mod 0 1 0 mem   | 2-4   | 16/24 + n    | 16/24 + n | temp ← CL, while CL ≠ 0 the following operations are repeated:<br>tmpcy ← CY, CY ← (mem) MSB<br>(mem) ← (mem) × 2 + tmpcy<br>temp ← temp – 1   |       | ×  | U |   |   |   |
|                     |          | reg, imm8  | 1 1 0 0 0 0 0 W | 1 1 0 1 0 reg   | 3     | 7 + n        | 7 + n     | temp ← imm8, while CL ≠ 0 the following operations are repeated:<br>tmpcy ← CY, CY ← reg MSB<br>reg ← reg × 2 + tmpcy<br>temp ← temp – 1       |       | ×  | U |   |   |   |
|                     |          | mem, imm8  | 1 1 0 0 0 0 0 W | mod 0 1 0 mem   | 3-5   | 16/24 + n    | 16/24 + n | temp ← imm8, while CL ≠ 0 the following operations are repeated:<br>tmpcy ← CY, CY ← (mem) MSB<br>(mem) ← (mem) × 2 + tmpcy<br>temp ← temp – 1 |       | ×  | U |   |   |   |

n: Number of shifts

| Instruction Group   | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |           | Operation                                                                                                                                                   | Flags |    |   |   |   |   |
|---------------------|----------|------------|-----------------|-----------------|-------|--------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                     |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL     |                                                                                                                                                             | AC    | CY | V | P | S | Z |
| Rotate instructions | RORC     | reg, 1     | 1 1 0 1 0 0 0 W | 1 1 0 1 1 reg   | 2     | 6            | 6         | tmpcy ← CY, CY ← reg LSB<br>reg ← reg ÷ 2<br>reg MSB ← tmpcy<br>reg MSB ≠ bit after reg MSB : V ← 1<br>reg MSB = bit after reg MSB : V ← 0                  |       | ×  | × |   |   |   |
|                     |          | mem, 1     | 1 1 0 1 0 0 0 W | mod 0 1 1 mem   | 2-4   | 13/21        | 13/21     | tmpcy ← CY, CY ← (mem) LSB<br>(mem) ← (mem) ÷ 2<br>(mem) MSB ← tmpcy<br>(mem) MSB ≠ bit after (mem) MSB : V ← 1<br>(mem) MSB = bit after (mem) MSB : V ← 0  |       | ×  | × |   |   |   |
|                     |          | reg, CL    | 1 1 0 1 0 0 1 W | 1 1 0 1 1 reg   | 2     | 7 + n        | 7 + n     | temp ← CL, while CL ≠ 0 the following operations are repeated:<br>tmpcy ← CY, CY ← reg LSB<br>reg ← reg ÷ 2<br>reg MSB ← tmpcy<br>temp ← temp – 1           |       | ×  | U |   |   |   |
|                     |          | mem, CL    | 1 1 0 1 0 0 1 W | mod 0 1 1 mem   | 2-4   | 16/24 + n    | 16/24 + n | temp ← CL, while CL ≠ 0 the following operations are repeated:<br>tmpcy ← CY, CY ← (mem) LSB<br>(mem) ← (mem) ÷ 2<br>(mem) MSB ← tmpcy<br>temp ← temp – 1   |       | ×  | U |   |   |   |
|                     |          | reg, imm8  | 1 1 0 0 0 0 0 W | 1 1 0 1 1 reg   | 3     | 7 + n        | 7 + n     | temp ← imm8, while CL ≠ 0 the following operations are repeated:<br>tmpcy ← CY, CY ← reg LSB<br>reg ← reg ÷ 2<br>reg MSB ← tmpcy<br>temp ← temp – 1         |       | ×  | U |   |   |   |
|                     |          | mem, imm8  | 1 1 0 0 0 0 0 W | mod 0 1 1 mem   | 3-5   | 16/24 + n    | 16/24 + n | temp ← imm8, while CL ≠ 0 the following operations are repeated:<br>tmpcy ← CY, CY ← (mem) LSB<br>(mem) ← (mem) ÷ 2<br>(mem) MSB ← tmpcy<br>temp ← temp – 1 |       | ×  | U |   |   |   |

n: Number of shifts

| Instruction Group               | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |       | Operation                                                                                                                  | Flags |    |   |   |   |   |
|---------------------------------|----------|------------|-----------------|-----------------|-------|--------------|-------|----------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                                 |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL |                                                                                                                            | AC    | CY | V | P | S | Z |
| Subroutine control instructions | CALL     | near-proc  | 1 1 1 0 1 0 0 0 |                 | 3     | 20           | 16/20 | SP ← SP – 2, (SP + 1, SP) ← PC<br>PC ← PC + disp                                                                           |       |    |   |   |   |   |
|                                 |          | regptr16   | 1 1 1 1 1 1 1 1 | 1 1 0 1 0 reg   | 2     | 18           | 14/18 | SP ← SP – 2, (SP + 1, SP) ← PC<br>PC ← regptr16                                                                            |       |    |   |   |   |   |
|                                 |          | memptr16   | 1 1 1 1 1 1 1 1 | mod 0 1 0 mem   | 2-4   | 31           | 23/31 | TA ← (memptr16)<br>SP ← SP – 2, (SP + 1, SP) ← PC, PC ← TA                                                                 |       |    |   |   |   |   |
|                                 |          | far-proc   | 1 0 0 1 1 0 1 0 |                 | 5     | 29           | 21/29 | SP ← SP – 2, (SP + 1, SP) ← PS, PS ← seg<br>SP ← SP – 2, (SP + 1, SP) ← PC, PC ← offset                                    |       |    |   |   |   |   |
|                                 |          | memptr32   | 1 1 1 1 1 1 1 1 | mod 0 1 1 mem   | 2-4   | 47           | 31/47 | TA ← (memptr32), TB ← (memptr32 + 2)<br>SP ← SP – 2, (SP + 1, SP) ← PS, PS ← TB<br>SP ← SP – 2, (SP + 1, SP) ← PC, PC ← TA |       |    |   |   |   |   |
|                                 | RET      |            | 1 1 0 0 0 0 1 1 |                 | 1     | 19           | 15/19 | PC ← (SP + 1, SP)<br>SP ← SP + 2                                                                                           |       |    |   |   |   |   |
|                                 |          | pop-value  | 1 1 0 0 0 0 1 0 |                 | 3     | 24           | 20/24 | PC ← (SP + 1, SP)<br>SP ← SP + 2, SP ← SP + pop-value                                                                      |       |    |   |   |   |   |
|                                 |          |            | 1 1 0 0 1 0 1 1 |                 | 1     | 29           | 21/29 | PC ← (SP + 1, SP)<br>PS ← (SP + 3, SP + 2)<br>PS ← SP + 4                                                                  |       |    |   |   |   |   |
|                                 |          | pop-value  | 1 1 0 0 1 0 1 0 |                 | 3     | 32           | 24/32 | PC ← (SP + 1, SP)<br>PS ← (SP + 3, SP + 2)<br>SP ← SP + 4, SP ← SP + pop-value                                             |       |    |   |   |   |   |

| Instruction Group               | Mnemonic | Operand(s)  | Operation Code   |                 | Bytes | Clock Cycles  |               | Operation                                                                          | Flags |    |   |   |   |   |
|---------------------------------|----------|-------------|------------------|-----------------|-------|---------------|---------------|------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                                 |          |             | 7 6 5 4 3 2 1 0  | 7 6 5 4 3 2 1 0 |       | V40HL         | V50HL         |                                                                                    | AC    | CY | V | P | S | Z |
| Stack manipulation instructions | PUSH     | mem16       | 1 1 1 1 1 1 1 1  | mod 1 1 0 mem   | 2-4   | 23            | 15/23         | $SP \leftarrow SP - 2$<br>$(SP + 1, SP) \leftarrow (mem16)$                        |       |    |   |   |   |   |
|                                 |          | reg16       | 0 1 0 1 0 reg    |                 | 1     | 10            | 6/10          | $SP \leftarrow SP - 2$<br>$(SP + 1, SP) \leftarrow reg16$                          |       |    |   |   |   |   |
|                                 |          | sreg        | 0 0 0 sreg 1 1 0 |                 | 1     | 10            | 6/10          | $SP \leftarrow SP - 2$<br>$(SP + 1, SP) \leftarrow sreg$                           |       |    |   |   |   |   |
|                                 |          | PSW         | 1 0 0 1 1 1 0 0  |                 | 1     | 10            | 6/10          | $SP \leftarrow SP - 2$<br>$(SP + 1, SP) \leftarrow PSW$                            |       |    |   |   |   |   |
|                                 |          | R           | 0 1 1 0 0 0 0 0  |                 | 1     | 65            | 33/65         | Push registers on the stack                                                        |       |    |   |   |   |   |
|                                 |          | imm8        | 0 1 1 0 1 0 1 0  |                 | 2     | 9             | 5/9           | $SP \leftarrow SP - 2$<br>$(SP + 1, SP) \leftarrow imm8, \text{sign of extension}$ |       |    |   |   |   |   |
|                                 |          | imm16       | 0 1 1 0 1 0 0 0  |                 | 3     | 10            | 6/10          | $SP \leftarrow SP - 2$<br>$(SP + 1, SP) \leftarrow imm16$                          |       |    |   |   |   |   |
|                                 | POP      | mem16       | 1 0 0 0 1 1 1 1  | mod 0 0 0 mem   | 2-4   | 24            | 16/24         | $(mem16) \leftarrow (SP + 1, SP)$<br>$SP \leftarrow SP + 2$                        |       |    |   |   |   |   |
|                                 |          | reg16       | 0 1 0 1 1 reg    |                 | 1     | 12            | 8/12          | $reg16 \leftarrow (SP + 1, SP)$<br>$SP \leftarrow SP + 2$                          |       |    |   |   |   |   |
|                                 |          | sreg        | 0 0 0 sreg 1 1 1 |                 | 1     | 12            | 8/12          | $sreg \leftarrow (SP + 1, SP)$<br>$SP \leftarrow SP + 2$ sreg : SS, DS0, DS1       |       |    |   |   |   |   |
|                                 |          | PSW         | 1 0 0 1 1 1 0 1  |                 | 1     | 12            | 8/12          | $PSW \leftarrow (SP + 1, SP)$<br>$SP \leftarrow SP + 2$                            | R     | R  | R | R | R | R |
|                                 |          | R           | 0 1 1 0 0 0 0 1  |                 | 1     | 75            | 43/75         | Pop registers from the stack                                                       |       |    |   |   |   |   |
|                                 | PREPARE  | imm16, imm8 | 1 1 0 0 1 0 0 0  |                 | 4     | <b>Note 1</b> | <b>Note 2</b> | Prepare New Stack Frame                                                            |       |    |   |   |   |   |
|                                 | DISPOSE  |             | 1 1 0 0 1 0 0 1  |                 | 1     | 10            | 6/10          | Dispose of Stack Frame                                                             |       |    |   |   |   |   |

- Notes 1.** If imm8 = 0 16  
 If imm8 ≥ 1 21 + 16 (imm8 – 1)
- 2.** If imm8 = 0 12/16  
 If imm8 ≥ 1 {17 + 8 (imm8 – 1)} / {21 + 16 (imm8 – 1)}

| Instruc-<br>tion<br>Group | Mnemonic | Operand(s)  | Operation Code  |                 | Bytes | Clock Cycles |       | Operation                              | Flags |    |   |   |   |   |
|---------------------------|----------|-------------|-----------------|-----------------|-------|--------------|-------|----------------------------------------|-------|----|---|---|---|---|
|                           |          |             | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL |                                        | AC    | CY | V | P | S | Z |
| Branch instructions       | BR       | near-label  | 1 1 1 0 1 0 0 1 |                 | 3     | 13           | 13    | PC ← PC+ dsip                          |       |    |   |   |   |   |
|                           |          | short-label | 1 1 1 0 1 0 1 1 |                 | 2     | 12           | 12    | PC ← PC+ ext-disp8                     |       |    |   |   |   |   |
|                           |          | regptr16    | 1 1 1 1 1 1 1 1 | 1 1 1 0 0 reg   | 2     | 11           | 11    | PC ← regptr16                          |       |    |   |   |   |   |
|                           |          | memptr16    | 1 1 1 1 1 1 1 1 | mod 1 0 0 mem   | 2-4   | 23           | 19/23 | PC ← (memptr16)                        |       |    |   |   |   |   |
|                           |          | far-label   | 1 1 1 0 1 0 1 0 |                 | 5     | 15           | 15    | PS ← seg<br>PC ← offset                |       |    |   |   |   |   |
|                           |          | memptr32    | 1 1 1 1 1 1 1 1 | mod 1 0 1 mem   | 2-4   | 34           | 26/34 | PS ← (memptr32 + 2)<br>PC ← (memptr32) |       |    |   |   |   |   |

| Instruction Group               | Mnemonic   | Operand(s)  | Operation Code  |                 | Bytes | Clock Cycles <sup>Note</sup> |       | Operation                                              | Flags |    |   |   |   |   |
|---------------------------------|------------|-------------|-----------------|-----------------|-------|------------------------------|-------|--------------------------------------------------------|-------|----|---|---|---|---|
|                                 |            |             | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL                        | V50HL |                                                        | AC    | CY | V | P | S | Z |
| Conditional branch instructions | BV         | short-label | 0 1 1 1 0 0 0 0 |                 | 2     | 14/4                         | 14/4  | if V = 1 PC ← PC + ext-disp8                           |       |    |   |   |   |   |
|                                 | BNV        | short-label |                 | 0 0 0 1         | 2     | 14/4                         | 14/4  | if V = 0 PC ← PC + ext-disp8                           |       |    |   |   |   |   |
|                                 | BC<br>BL   | short-label |                 | 0 0 1 0         | 2     | 14/4                         | 14/4  | if CY = 1 PC ← PC + ext-disp8                          |       |    |   |   |   |   |
|                                 | BNC<br>BNL | short-label |                 | 0 0 1 1         | 2     | 14/4                         | 14/4  | if CY = 0 PC ← PC + ext-disp8                          |       |    |   |   |   |   |
|                                 | BE<br>BZ   | short-label |                 | 0 1 0 0         | 2     | 14/4                         | 14/4  | if Z = 1 PC ← PC + ext-disp8                           |       |    |   |   |   |   |
|                                 | BNE<br>BNZ | short-label |                 | 0 1 0 1         | 2     | 14/4                         | 14/4  | if Z = 0 PC ← PC + ext-disp8                           |       |    |   |   |   |   |
|                                 | BNH        | short-label |                 | 0 1 1 0         | 2     | 14/4                         | 14/4  | if CY ∨ Z = 1 PC ← PC + ext-disp8                      |       |    |   |   |   |   |
|                                 | BH         | short-label |                 | 0 1 1 1         | 2     | 14/4                         | 14/4  | if CY ∨ Z = 0 PC ← PC + ext-disp8                      |       |    |   |   |   |   |
|                                 | BN         | short-label |                 | 1 0 0 0         | 2     | 14/4                         | 14/4  | if S = 1 PC ← PC + ext-disp8                           |       |    |   |   |   |   |
|                                 | BP         | short-label |                 | 1 0 0 1         | 2     | 14/4                         | 14/4  | if S = 0 PC ← PC + ext-disp8                           |       |    |   |   |   |   |
|                                 | BPE        | short-label |                 | 1 0 1 0         | 2     | 14/4                         | 14/4  | if P = 1 PC ← PC + ext-disp8                           |       |    |   |   |   |   |
|                                 | BPO        | short-label |                 | 1 0 1 1         | 2     | 14/4                         | 14/4  | if P = 0 PC ← PC + ext-disp8                           |       |    |   |   |   |   |
|                                 | BLT        | short-label |                 | 1 1 0 0         | 2     | 14/4                         | 14/4  | if S ∨ V = 1 PC ← PC + ext-disp8                       |       |    |   |   |   |   |
|                                 | BGE        | short-label |                 | 1 1 0 1         | 2     | 14/4                         | 14/4  | if S ∨ V = 0 PC ← PC + ext-disp8                       |       |    |   |   |   |   |
|                                 | BLE        | short-label |                 | 1 1 1 0         | 2     | 14/4                         | 14/4  | if (S ∨ V) ∨ Z = 1 PC ← PC + ext-disp8                 |       |    |   |   |   |   |
|                                 | BGT        | short-label | ↓               | 1 1 1 1         | 2     | 14/4                         | 14/4  | if (S ∨ V) ∨ Z = 0 PC ← PC + ext-disp8                 |       |    |   |   |   |   |
|                                 | DBNZNE     | short-label | 1 1 1 0 0 0 0 0 |                 | 2     | 14/5                         | 14/5  | CW = CW – 1<br>if Z = 0 and CW ≠ 0 PC ← PC + ext-disp8 |       |    |   |   |   |   |
|                                 | DBNZE      | short-label | 1 1 1 0 0 0 0 1 |                 | 2     | 14/5                         | 14/5  | CW = CW – 1<br>if Z = 1 and CW ≠ 0 PC ← PC + ext-disp8 |       |    |   |   |   |   |
|                                 | DBNZ       | short-label | 1 1 1 0 0 0 1 0 |                 | 2     | 13/5                         | 13/5  | CW = CW – 1<br>if CW ≠ 0 PC ← PC + ext-disp8           |       |    |   |   |   |   |
|                                 | BCWZ       | short-label | 1 1 1 0 0 0 1 1 |                 | 2     | 13/5                         | 13/5  | if CW = 0 PC ← PC + ext-disp8                          |       |    |   |   |   |   |

**Note** Condition determination: true/false

| Instruction Group      | Mnemonic | Operand(s)    | Operation Code  |                 | Bytes | Clock Cycles |        | Operation                                                                                                                                                                                                                   | Flags |    |   |   |   |   |
|------------------------|----------|---------------|-----------------|-----------------|-------|--------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                        |          |               | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL  |                                                                                                                                                                                                                             | AC    | CY | V | P | S | Z |
| Interrupt instructions | BRK      | 3             | 1 1 0 0 1 1 0 0 |                 | 1     | 50           | 38/50  | TA ← (00DH, 00CH), TC ← (00FH, 00EH)<br>SP ← SP - 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0<br>SP ← SP - 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP - 2, (SP + 1, SP) ← PC, PC ← TA                                              |       |    |   |   |   |   |
|                        |          | imm8<br>(= 3) | 1 1 0 0 1 1 0 1 |                 | 2     | 50           | 38/50  | TA ← (4 n + 1, 4n), TC ← (4n + 3, 4n + 2) n = imm8<br>SP ← SP - 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0<br>SP ← SP - 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP - 2, (SP + 1, SP) ← PC, PC ← TA                                |       |    |   |   |   |   |
|                        | BRKV     |               | 1 1 0 0 1 1 1 0 |                 | 1     | Note 1       | Note 2 | If V = 1<br>TA ← (011H, 010H), TC ← (013H, 012H)<br>SP ← SP - 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0<br>SP ← SP - 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP - 2, (SP + 1, SP) ← PC, PC ← TA                                  |       |    |   |   |   |   |
|                        | RETI     |               | 1 1 0 0 1 1 1 1 |                 | 1     | 39           | 27/39  | PC ← (SP + 1, SP), PS ← (SP + 3, SP + 2),<br>PSW ← (SP + 5, SP + 4), SP ← SP + 6                                                                                                                                            | R     | R  | R | R | R | R |
|                        | BRKEM    | imm8          | 0 0 0 0 1 1 1 1 | 1 1 1 1 1 1 1 1 | 3     | 50           | 38/50  | TA ← (4 n + 1, 4n), TC ← (4n + 3, 4n + 2) n = imm8<br>SP ← SP - 2, (SP + 1, SP) ← PSW, MD ← 0<br>MD is set to write enabled<br>SP ← SP - 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP - 2, (SP + 1, SP) ← PC, PC ← TA           |       |    |   |   |   |   |
|                        | CHKIND   | reg16, mem32  | 0 1 1 0 0 0 1 0 | mod reg mem     | 2-4   | Note 3       | Note 4 | If (mem32) > reg16 or (mem32 + 2) < reg16<br>TA ← (015H, 014H), TC ← (017H, 016H)<br>SP ← SP - 2, (SP + 1, SP) ← PSW, IE ← 0, BRK ← 0<br>SP ← SP - 2, (SP + 1, SP) ← PS, PS ← TC<br>SP ← SP - 2, (SP + 1, SP) ← PC, PC ← TA |       |    |   |   |   |   |

- Notes**
1. When V = 1: 52  
When V = 0: 3
  2. When V = 1: 40/52  
When V = 0: 3
  3. When interrupt condition is established : 72 to 75  
When interrupt condition is not established : 25
  4. When interrupt condition is established : (52 to 55)/(72 to 75)  
When interrupt condition is not established : 17/25

| Instruction Group        | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |        | Operation                                                                | Flags |    |   |   |   |   |
|--------------------------|----------|------------|-----------------|-----------------|-------|--------------|--------|--------------------------------------------------------------------------|-------|----|---|---|---|---|
|                          |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL  |                                                                          | AC    | CY | V | P | S | Z |
| CPU control instructions | HALT     |            | 1 1 1 1 0 1 0 0 |                 | 1     | 2            | 2      | CPU Halt                                                                 |       |    |   |   |   |   |
|                          | POLL     |            | 1 0 0 1 1 0 1 1 |                 | 1     | 2 + 5n       | 2 + 5n | Poll and wait n: Number of times $\overline{\text{POLL}}$ pin is sampled |       |    |   |   |   |   |
|                          | DI       |            | 1 1 1 1 1 0 1 0 |                 | 1     | 2            | 2      | IE $\leftarrow$ 0                                                        |       |    |   |   |   |   |
|                          | EI       |            | 1 1 1 1 1 0 1 1 |                 | 1     | 2            | 2      | IE $\leftarrow$ 1                                                        |       |    |   |   |   |   |
|                          | BUSLOCK  |            | 1 1 1 1 0 0 0 0 |                 | 1     | 2            | 2      | Bus Lock Prefix                                                          |       |    |   |   |   |   |
|                          | FPO1     | fp-op      | 1 1 0 1 1 X X X | 1 1 Y Y Y Z Z Z | 2     | 2            | 2      | No Operation                                                             |       |    |   |   |   |   |
|                          |          | fp-op, mem | 1 1 0 1 1 X X X | mod Y Y Y mem   | 2-4   | 14           | 10/14  | data bus $\leftarrow$ (mem)                                              |       |    |   |   |   |   |
|                          | FPO2     | fp-op      | 0 1 1 0 0 1 1 X | 1 1 Y Y Y Z Z Z | 2     | 2            | 2      | No Operation                                                             |       |    |   |   |   |   |
|                          |          | fp-op, mem | 0 1 1 0 0 1 1 X | mod Y Y Y mem   | 2-4   | 14           | 10/14  | data bus $\leftarrow$ (mem)                                              |       |    |   |   |   |   |
|                          | NOP      |            | 1 0 0 1 0 0 0 0 |                 | 1     | 3            | 3      | No Operation                                                             |       |    |   |   |   |   |

|  |   |  |                  |  |   |   |   |                         |  |  |  |  |  |  |
|--|---|--|------------------|--|---|---|---|-------------------------|--|--|--|--|--|--|
|  | * |  | 0 0 1 sreg 1 1 0 |  | 1 | 2 | 2 | Segment override prefix |  |  |  |  |  |  |
|--|---|--|------------------|--|---|---|---|-------------------------|--|--|--|--|--|--|

\* DS0:, DS1:, PS:, and SS:.

| Instruction Group | Mnemonic | Operand(s) | Operation Code  |                 | Bytes | Clock Cycles |       | Operation                                                                                                                                                                                                                                                                                                   | Flags |    |   |   |   |   |
|-------------------|----------|------------|-----------------|-----------------|-------|--------------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----|---|---|---|---|
|                   |          |            | 7 6 5 4 3 2 1 0 | 7 6 5 4 3 2 1 0 |       | V40HL        | V50HL |                                                                                                                                                                                                                                                                                                             | AC    | CY | V | P | S | Z |
| 8080              | RETEM    |            | 1 1 1 0 1 1 0 1 | 1 1 1 1 1 1 0 1 | 2     | 39           | 27/39 | PC $\leftarrow$ (SP + 1, SP), PS $\leftarrow$ (SP + 3, SP + 2),<br>PSW $\leftarrow$ (SP + 5, SP + 4), SP $\leftarrow$ SP + 6, MD is set to write disabled                                                                                                                                                   | R     | R  | R | R | R | R |
|                   | CALLN    | imm8       | 1 1 1 0 1 1 0 1 | 1 1 1 0 1 1 0 1 | 3     | 58           | 38/58 | TA $\leftarrow$ (4n + 1, 4n), TC $\leftarrow$ (4n + 3, 4n + 2) n = imm8<br>SP $\leftarrow$ SP - 2, (SP + 1, SP) $\leftarrow$ PSW, MD $\leftarrow$ 1<br>SP $\leftarrow$ SP - 2, (SP + 1, SP) $\leftarrow$ PS, PS $\leftarrow$ TC<br>SP $\leftarrow$ SP - 2, (SP + 1, SP) $\leftarrow$ PC, PC $\leftarrow$ TA |       |    |   |   |   |   |

## 16. ELECTRICAL SPECIFICATIONS

### Applied standard

The electrical characteristics shown below are applied to devices other than the old models conforming to K mask.

Therefore, these characteristics are different from those conforming to the K mask. For the electrical characteristics of the K mask, consult NEC.

“Others” in the table below means products conforming to the masks other than E, P, X, and M (but conforming to the L, F mask).

### 16.1 AT 5 V OPERATION

#### OPERATING RANGE

|                            | E, P, X, M Mask Model          | Others                        |
|----------------------------|--------------------------------|-------------------------------|
| μPD70208H, 70216H-10/12/16 | $V_{DD} = 5\text{ V} \pm 10\%$ |                               |
| μPD70208H, 70216H-20       | —                              | $V_{DD} = 5\text{ V} \pm 5\%$ |

#### ABSOLUTE MAXIMUM RATINGS ( $T_A = 25\text{ }^{\circ}\text{C}$ )

| Parameter                     | Symbol    | Test Conditions                                                                                                           | Rating                 | Unit               |
|-------------------------------|-----------|---------------------------------------------------------------------------------------------------------------------------|------------------------|--------------------|
| Supply voltage                | $V_{DD}$  |                                                                                                                           | −0.5 to +7.0           | V                  |
| Input voltage                 | $V_I$     | $V_{DD} = 5\text{ V} \pm 10\%$<br>(μPD70208H, 70216H-10/12/16)<br>$V_{DD} = 5\text{ V} \pm 5\%$<br>(μPD70208H, 70216H-20) | −0.5 to $V_{DD} + 0.3$ | V                  |
| Clock input voltage           | $V_K$     |                                                                                                                           | −0.5 to $V_{DD} + 1.0$ | V                  |
| Output voltage                | $V_O$     |                                                                                                                           | −0.5 to $V_{DD} + 0.3$ | V                  |
| Operating ambient temperature | $T_A$     |                                                                                                                           | −40 to +85             | $^{\circ}\text{C}$ |
| Storage temperature           | $T_{stg}$ |                                                                                                                           | −65 to +150            | $^{\circ}\text{C}$ |

**Cautions** 1. Do not directly connect the output pins of two or more IC products and do not directly connect the output pins to  $V_{DD}$  or  $V_{CC}$  and GND. However, open-drain pins or open-collector pins may be connected directly. Moreover, an external circuit whose timing is designed to avoid output collision can be connected to pins that go into a high-impedance state.

2. If even one of the above parameters exceeds the absolute maximum rating even momentarily, the quality of the program may be degraded. Absolute maximum ratings, therefore, are the values exceeding which the product may be physically damaged. Use the program keeping all the parameters within these rated values.

The standards and conditions shown in DC and AC Characteristics below specify the range within which the normal operation of the product is guaranteed.

## DC CHARACTERISTICS

(T<sub>A</sub> = -40 to +85 °C, V<sub>DD</sub> = 5 V  $\pm$ 10% ( $\mu$ PD70208H, 70216H-10/12/16), V<sub>DD</sub> = 5 V  $\pm$ 5% ( $\mu$ PD70208H, 70216H-20))

| Parameter                                   | Symbol            | Test Conditions                                              |                                                                             | MIN.                  | TYP.               | MAX.                 | Unit    |
|---------------------------------------------|-------------------|--------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------|--------------------|----------------------|---------|
| Input voltage high                          | V <sub>IH</sub>   | E, P, X, M masks                                             | Except $\overline{\text{RESET}}$                                            | 2.2                   |                    | V <sub>DD</sub> +0.3 | V       |
|                                             |                   |                                                              | $\overline{\text{RESET}}$                                                   | 0.8 V <sub>DD</sub>   |                    | V <sub>DD</sub> +0.3 |         |
|                                             |                   | Others                                                       | Except $\overline{\text{RESET}}$ , INT <sub>P</sub> 1 to INT <sub>P</sub> 7 | 2.2                   |                    | V <sub>DD</sub> +0.3 |         |
|                                             |                   |                                                              | $\overline{\text{RESET}}$                                                   | 0.8 V <sub>DD</sub>   |                    | V <sub>DD</sub> +0.3 |         |
|                                             |                   |                                                              | INT <sub>P</sub> 1 to INT <sub>P</sub> 7                                    | 2.4                   |                    | V <sub>DD</sub> +0.3 |         |
| Input voltage low                           | V <sub>IL</sub>   | Except $\overline{\text{RESET}}$                             |                                                                             | -0.5                  |                    | +0.8                 | V       |
|                                             |                   | $\overline{\text{RESET}}$                                    |                                                                             | -0.5                  |                    | 0.2V <sub>DD</sub>   |         |
| Clock input voltage high                    | V <sub>KH</sub>   |                                                              |                                                                             | 3.9                   |                    | V <sub>DD</sub> +1.0 | V       |
| Clock input voltage low                     | V <sub>KL</sub>   |                                                              |                                                                             | -0.5                  |                    | +0.6                 | V       |
| Output voltage high                         | V <sub>OH</sub>   | I <sub>OH</sub> = -2.5 mA                                    |                                                                             | 0.7 V <sub>DD</sub>   |                    |                      | V       |
|                                             |                   | I <sub>OH</sub> = -100 $\mu$ A                               |                                                                             | V <sub>DD</sub> - 0.4 |                    |                      |         |
| Output voltage low                          | V <sub>OL</sub>   | Except $\overline{\text{END/TC}}$ : I <sub>OL</sub> = 2.5 mA |                                                                             |                       |                    | 0.4                  | V       |
|                                             |                   | $\overline{\text{END/TC}}$ : I <sub>OL</sub> = 5.0 mA        |                                                                             |                       |                    |                      |         |
| Input leak current high                     | I <sub>LIH</sub>  | V <sub>I</sub> = V <sub>DD</sub>                             |                                                                             |                       |                    | 10                   | $\mu$ A |
| Input leak current low                      | I <sub>LIL</sub>  | Except INT <sub>P</sub> : V <sub>I</sub> = 0 V               |                                                                             |                       |                    | -10                  | $\mu$ A |
| INT <sub>P</sub> input current low          | I <sub>LIPL</sub> | INT <sub>P</sub> input: V <sub>I</sub> = 0 V                 |                                                                             |                       |                    | -300                 | $\mu$ A |
| Output leak current high                    | I <sub>LOH</sub>  | V <sub>O</sub> = V <sub>DD</sub>                             |                                                                             |                       |                    | 10                   | $\mu$ A |
| Output leak current low                     | I <sub>LOL</sub>  | V <sub>O</sub> = 0 V                                         |                                                                             |                       |                    | -10                  | $\mu$ A |
| Latch leak current high                     | I <sub>LLH</sub>  | V <sub>I</sub> = 3.0 V                                       |                                                                             | -50                   |                    | -300                 | $\mu$ A |
| Latch leak current low                      | I <sub>LLL</sub>  | V <sub>I</sub> = 0.8 V                                       |                                                                             | 50                    |                    | 300                  | $\mu$ A |
| Latch inversion current (L $\rightarrow$ H) | I <sub>ILH</sub>  |                                                              |                                                                             |                       |                    | 400                  | $\mu$ A |
| Latch inversion current (H $\rightarrow$ L) | I <sub>ILL</sub>  |                                                              |                                                                             |                       |                    | -400                 | $\mu$ A |
| Supply current <sup>Note</sup>              | I <sub>DD</sub>   | E, P, X, M masks                                             | On operation                                                                |                       | 5.5 f <sub>x</sub> | 9.0 f <sub>x</sub>   | mA      |
|                                             |                   |                                                              | On standby (HALT)                                                           |                       | 1.5 f <sub>x</sub> | 2.5 f <sub>x</sub>   |         |
|                                             |                   |                                                              | On standby (STOP)                                                           |                       |                    | 50                   | $\mu$ A |
|                                             |                   | Others                                                       | On operation                                                                |                       | 4.5 f <sub>x</sub> | 6.0 f <sub>x</sub>   | mA      |
|                                             |                   |                                                              | On standby (HALT)                                                           |                       | 1.5 f <sub>x</sub> | 2.2 f <sub>x</sub>   |         |
|                                             |                   |                                                              | On standby (STOP)                                                           |                       |                    | 50                   | $\mu$ A |

**Note** The unit of constant values (1.5, 2.2, 2.5, 4.5, 5.5, 6.0 and 9.0) is mA/MHz.CAPACITANCE (T<sub>A</sub> = 25 °C, V<sub>DD</sub> = 0 V)

| Parameter                | Symbol          | Test Conditions          | MIN. | TYP. | MAX. | Unit |
|--------------------------|-----------------|--------------------------|------|------|------|------|
| Input capacitance        | C <sub>I</sub>  | f <sub>c</sub> = 1 MHz   |      |      | 10   | pF   |
| Input/output capacitance | C <sub>IO</sub> | 0 V other than test pin. |      |      | 15   | pF   |

## AC CHARACTERISTICS

(1)  $\mu$ PD70208H, 70216H-10/12/16 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 5$  V  $\pm 10\%$ ) (1/3)Output Pin Load Capacitance:  $C_L = 100$  pF

| Parameter                                                        | Symbol                            | $\mu$ PD70208H-10<br>$\mu$ PD70216H-10 |      | $\mu$ PD70208H-12<br>$\mu$ PD70216H-12 |      | $\mu$ PD70208H-16<br>$\mu$ PD70216H-16 |      | Unit |
|------------------------------------------------------------------|-----------------------------------|----------------------------------------|------|----------------------------------------|------|----------------------------------------|------|------|
|                                                                  |                                   | MIN.                                   | MAX. | MIN.                                   | MAX. | MIN.                                   | MAX. |      |
| External clock input cycle                                       | <1> $t_{CYX}$                     | 50                                     | DC   | 40                                     | DC   | 31.25                                  | DC   | ns   |
| External clock input high-level width ( $V_{KH}=3.0$ V)          | <2> $t_{XXH}$                     | 19                                     |      | 14                                     |      | 12                                     |      | ns   |
| External clock input low-level width ( $V_{KL}=1.5$ V)           | <3> $t_{XXL}$                     | 19                                     |      | 14                                     |      | 12                                     |      | ns   |
| External clock input rise time (1.5→3.0 V)                       | <4> $t_{XR}$                      |                                        | 5    |                                        | 5    |                                        | 5    | ns   |
| External clock input fall time (3.0→1.5 V)                       | <5> $t_{XF}$                      |                                        | 5    |                                        | 5    |                                        | 5    | ns   |
| Clock output cycle                                               | <6> $t_{CYK}$                     | 100                                    | DC   | 80                                     | DC   | 62.5                                   | DC   | ns   |
| Clock output high-level width ( $V_{OH}=3.0$ V)                  | <7> $t_{KKH}$                     | $0.5t_{CYK}-5$                         |      | $0.5t_{CYK}-5$                         |      | $0.5t_{CYK}-5$                         |      | ns   |
| Clock output low-level width ( $V_{OL}=1.5$ V)                   | <8> $t_{KKL}$                     | $0.5t_{CYK}-5$                         |      | $0.5t_{CYK}-5$                         |      | $0.5t_{CYK}-5$                         |      | ns   |
| Clock output rise time (1.5→3.0 V)                               | <9> $t_{KR}$                      |                                        | 5    |                                        | 5    |                                        | 5    | ns   |
| Clock output fall time (3.0→1.5 V)                               | <10> $t_{KF}$                     |                                        | 5    |                                        | 5    |                                        | 5    | ns   |
| CLKOUT delay time (vs. external clock)                           | <11> $t_{DXK}$                    |                                        | 40   |                                        | 35   |                                        | 20   | ns   |
| Input rise time (except external clock) (0.8→2.2 V)              | <12> $t_{IR}$                     |                                        | 15   |                                        | 15   |                                        | 15   | ns   |
| Input fall time (except external clock) (2.2→0.8 V)              | <13> $t_{IF}$                     |                                        | 10   |                                        | 10   |                                        | 10   | ns   |
| Output rise time<br>(except CLKOUT) (0.8→2.2 V)                  | E, P, X, M masks<br><14> $t_{OR}$ |                                        | 15   |                                        | 15   |                                        | 15   | ns   |
|                                                                  | Others                            |                                        | 10   |                                        | 10   |                                        | 10   | ns   |
| Output fall time (except CLKOUT) (2.2→0.8 V)                     | <15> $t_{OF}$                     |                                        | 10   |                                        | 10   |                                        | 10   | ns   |
| $\overline{\text{RESET}}$ setup time (vs. CLKOUT↓) <b>Note 1</b> | <16> $t_{SRESK}$                  | 20                                     |      | 20                                     |      | 20                                     |      | ns   |
| $\overline{\text{RESET}}$ hold time (vs. CLKOUT↓) <b>Note 1</b>  | <17> $t_{HKRES}$                  | 25                                     |      | 25                                     |      | 15                                     |      | ns   |
| RESOUT output delay time (vs. CLKOUT↓)                           | <18> $t_{DKRES}$                  | 5                                      | 50   | 5                                      | 40   | 5                                      | 30   | ns   |
| READY inactive setup time (vs. CLKOUT↑)                          | <19> $t_{SRYLK}$                  | 15                                     |      | 10                                     |      | 7                                      |      | ns   |
| READY inactive hold time (vs. CLKOUT↑)                           | <20> $t_{HKRYL}$                  | 20                                     |      | 15                                     |      | 15                                     |      | ns   |
| READY active setup time (vs. CLKOUT↑)                            | <21> $t_{SRYHK}$                  | 15                                     |      | 10                                     |      | 7                                      |      | ns   |
| READY active hold time (vs. CLKOUT↑)                             | <22> $t_{HKRYH}$                  | 20                                     |      | 20                                     |      | 15                                     |      | ns   |
| NMI setup time (vs. CLKOUT↑)                                     | <23> $t_{SNMIK}$                  | 15                                     |      | 15                                     |      | 15                                     |      | ns   |
| POLL setup time (vs. CLKOUT↑)                                    | <24> $t_{SPOLK}$                  | 20                                     |      | 20                                     |      | 20                                     |      | ns   |
| Data setup time (vs. CLKOUT↓)                                    | <25> $t_{SDK}$                    | 15                                     |      | 10                                     |      | 7                                      |      | ns   |
| Data hold time (vs. CLKOUT↓)                                     | <26> $t_{HKD}$                    | 5                                      |      | 5                                      |      | 5                                      |      | ns   |
| CLKOUT → address delay time <b>Note 2</b>                        | <27> $t_{DKA}$                    | 5                                      | 50   | 5                                      | 40   | 5                                      | 28   | ns   |
| ★ CLKOUT → address hold time                                     | <28> $t_{HKA}$                    | 5                                      |      | 5                                      |      | 5                                      |      | ns   |
| CLKOUT↓ → PS delay time                                          | <29> $t_{DKP}$                    | 5                                      | 50   | 5                                      | 40   | 5                                      | 30   | ns   |
| CLKOUT↓ → PS float delay time                                    | <30> $t_{FKP}$                    | 5                                      | 50   | 5                                      | 40   | 5                                      | 30   | ns   |
| Address setup time (vs. ASTB↓)                                   | <31> $t_{SAST}$ $t_{KKL}-20$      |                                        |      | $t_{KKL}-10$                           |      | $t_{KKL}-10$                           |      | ns   |
| CLKOUT↓ → address float delay time <b>Note 3</b>                 | <32> $t_{FKA}$ $t_{HKA}$          |                                        | 50   | $t_{HKA}$                              | 40   | $t_{HKA}$                              | 30   | ns   |
| CLKOUT↓ → ASTB↑ delay time                                       | <33> $t_{DKSTH}$                  |                                        | 40   |                                        | 30   |                                        | 25   | ns   |

- Notes**
1. When reset with the minimum pulse width or when guaranteeing the RESOUT output timing.
  2. Specifications also corresponding to the QS0, QS1, and  $\overline{\text{BUSLOCK}}$  signals, and A16/PS0-A19/PS3,  $\overline{\text{UBE}}$ ,  $\overline{\text{BUFEN}}$ ,  $\overline{\text{BUFR/W}}$ ,  $\overline{\text{MRD}}$ ,  $\overline{\text{IORD}}$ ,  $\overline{\text{MWR}}$ ,  $\overline{\text{IOWR}}$ , and BS0-BS2 signals at HLDRQ/HLDAK timing.
  3. Specifications also corresponding to the A16/PS0-A19/PS3,  $\overline{\text{UBE}}$ ,  $\overline{\text{BUFEN}}$ ,  $\overline{\text{BUFR/W}}$ ,  $\overline{\text{MRD}}$ ,  $\overline{\text{IORD}}$ ,  $\overline{\text{MWR}}$ ,  $\overline{\text{IOWR}}$ , and BS0-BS2 signals at HLDRQ/HLDAK timing.

(1)  $\mu$ PD70208H, 70216H-10/12/16 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 5$  V  $\pm 10\%$ ) (2/3)Output Pin Load Capacitance:  $C_L = 100$  pF

| Parameter                                                                                                       | Symbol             | $\mu$ PD70208H-10<br>$\mu$ PD70216H-10 |               | $\mu$ PD70208H-12<br>$\mu$ PD70216H-12 |               | $\mu$ PD70208H-16<br>$\mu$ PD70216H-16 |               | Unit |
|-----------------------------------------------------------------------------------------------------------------|--------------------|----------------------------------------|---------------|----------------------------------------|---------------|----------------------------------------|---------------|------|
|                                                                                                                 |                    | MIN.                                   | MAX.          | MIN.                                   | MAX.          | MIN.                                   | MAX.          |      |
| CLKOUT $\uparrow$ $\rightarrow$ ASTB $\downarrow$ delay time                                                    | <34> $t_{DKSTL}$   |                                        | 45            |                                        | 35            |                                        | 30            | ns   |
| ASTB high-level width                                                                                           | <35> $t_{STST}$    | $t_{KKL}-10$                           |               | $t_{KKL}-10$                           |               | $t_{KKL}-10$                           |               | ns   |
| ASTB $\downarrow$ $\rightarrow$ address hold time                                                               | <36> $t_{HSTA}$    | $t_{KKH}-20$                           |               | $t_{KKH}-10$                           |               | $t_{KKH}-10$                           |               | ns   |
| CLKOUT $\rightarrow$ control 1 <sup>Note 1</sup> delay time                                                     | <37> $t_{DKCT1}$   | 5                                      | 60            | 5                                      | 50            | 5                                      | 40            | ns   |
| CLKOUT $\rightarrow$ control 2 <sup>Note 2</sup> delay time                                                     | <38> $t_{DKCT2}$   | 5                                      | 55            | 5                                      | 45            | 5                                      | 35            | ns   |
| Address float $\rightarrow$ $\overline{RD}\downarrow$ delay time                                                | <39> $t_{DAFRL}$   | 0                                      |               | 0                                      |               | 0                                      |               | ns   |
| CLKOUT $\downarrow$ $\rightarrow$ $\overline{RD}\downarrow$ delay time                                          | <40> $t_{DKRL}$    | 5                                      | 65            | 5                                      | 50            | 5                                      | 40            | ns   |
| CLKOUT $\downarrow$ $\rightarrow$ $\overline{RD}\uparrow$ delay time                                            | <41> $t_{DKRH}$    | 5                                      | 60            | 5                                      | 45            | 5                                      | 35            | ns   |
| $\overline{RD}\uparrow$ $\rightarrow$ address delay time                                                        | <42> $t_{DRHA}$    | $t_{CYK}-40$                           |               | $t_{CYK}-20$                           |               | $t_{CYK}-10$                           |               | ns   |
| $\overline{RD}$ low-level width                                                                                 | <43> $t_{RR}$      | $2t_{CYK}-40$                          |               | $2t_{CYK}-20$                          |               | $2t_{CYK}-20$                          |               | ns   |
| $\overline{BUFEN}\uparrow$ $\rightarrow$ $\overline{BUFR}/W$ delay time (read cycle)                            | <44> $t_{DBECT}$   | $t_{KKL}-20$                           |               | $t_{KKL}-10$                           |               | $t_{KKL}-10$                           |               | ns   |
| CLKOUT $\downarrow$ $\rightarrow$ data output delay time                                                        | <45> $t_{DKD}$     | 5                                      | 55            | 5                                      | 40            | 5                                      | 30            | ns   |
| CLKOUT $\downarrow$ $\rightarrow$ data float delay time                                                         | <46> $t_{FKD}$     | 5                                      | 55            | 5                                      | 40            | 5                                      | 30            | ns   |
| $\overline{WR}$ low-level width                                                                                 | <47> $t_{WW}$      | $2t_{CYK}-40$                          |               | $2t_{CYK}-20$                          |               | $2t_{CYK}-20$                          |               | ns   |
| $\overline{WR}\uparrow$ $\rightarrow$ $\overline{BUFEN}\uparrow$ or $\overline{BUFR}/W\downarrow$ (write cycle) | <48> $t_{DWCT}$    | $t_{KKL}-20$                           |               | $t_{KKL}-10$                           |               | $t_{KKL}-10$                           |               | ns   |
| CLKOUT $\uparrow$ $\rightarrow$ BS $\downarrow$ delay time                                                      | <49> $t_{DKBL}$    | 5                                      | 55            | 5                                      | 40            | 5                                      | 30            | ns   |
| CLKOUT $\downarrow$ $\rightarrow$ BS $\uparrow$ delay time                                                      | <50> $t_{DKBH}$    | 5                                      | 55            | 5                                      | 40            | 5                                      | 30            | ns   |
| HLD $\overline{RQ}$ setup time (vs. CLKOUT $\downarrow$ )                                                       | <51> $t_{SHQK}$    | 15                                     |               | 10                                     |               | 7                                      |               | ns   |
| CLKOUT $\downarrow$ $\rightarrow$ HLD $\overline{AK}$ delay time                                                | <52> $t_{DKHA}$    | 5                                      | 60            | 5                                      | 50            | 5                                      | 40            | ns   |
| CLKOUT $\uparrow$ $\rightarrow$ $\overline{DMAAK}$ delay time                                                   | <53> $t_{DKHDA}$   | 5                                      | 55            | 5                                      | 45            | 5                                      | 35            | ns   |
| CLKOUT $\downarrow$ $\rightarrow$ $\overline{DMAAK}$ delay time (cascade mode)                                  | <54> $t_{DKLDA}$   | 5                                      | 80            | 5                                      | 70            | 5                                      | 55            | ns   |
| $\overline{WR}$ low-level width<br>(DMA cycle)                                                                  | DMA extended write | <55> $t_{WW1}$                         | $2t_{CYK}-40$ |                                        | $2t_{CYK}-20$ |                                        | $2t_{CYK}-20$ | ns   |
|                                                                                                                 | DMA normal write   | <56> $t_{WW2}$                         | $t_{CYK}-40$  |                                        | $t_{CYK}-20$  |                                        | $t_{CYK}-15$  | ns   |
| $\overline{RD}\downarrow$ , $\overline{WR}\downarrow$ delay time (vs. $\overline{DMAAK}\downarrow$ )            | <57> $t_{DDARW}$   | $t_{KKH}-30$                           |               | $t_{KKH}-20$                           |               | $t_{KKH}-15$                           |               | ns   |
| $\overline{DMAAK}\uparrow$ delay time (vs. $\overline{RD}\uparrow$ )                                            | <58> $t_{DRHDAH}$  | $t_{KKL}-30$                           |               | $t_{KKL}-20$                           |               | $t_{KKL}-15$                           |               | ns   |
| $\overline{RD}\uparrow$ delay time (vs. $\overline{WR}\uparrow$ )                                               | <59> $t_{DWHRH}$   | 3                                      |               | 3                                      |               | 3                                      |               | ns   |
| $\overline{TC}$ output delay time (vs. CLKOUT $\uparrow$ )                                                      | <60> $t_{DKTCL}$   |                                        | 55            |                                        | 45            |                                        | 35            | ns   |
| $\overline{TC}$ OFF delay time (vs. CLKOUT $\uparrow$ )                                                         | <61> $t_{DKTCF}$   |                                        | 55            |                                        | 45            |                                        | 35            | ns   |
| $\overline{TC}$ low-level width                                                                                 | <62> $t_{TCTCL}$   | $t_{CYK}-15$                           |               | $t_{CYK}-10$                           |               | $t_{CYK}-10$                           |               | ns   |
| $\overline{TC}$ pull-up delay time (vs. CLKOUT $\uparrow$ )                                                     | <63> $t_{DKTCH}$   |                                        | Note 3        |                                        | Note 4        |                                        | Note 4        | ns   |
| $\overline{END}$ setup time (vs. CLKOUT $\uparrow$ )                                                            | <64> $t_{SEDK}$    | 30                                     |               | 25                                     |               | 20                                     |               | ns   |
| $\overline{END}$ low-level width                                                                                | <65> $t_{EEDL}$    | 80                                     |               | 65                                     |               | 50                                     |               | ns   |
| $\overline{DMARQ}$ setup time (vs. CLKOUT $\uparrow$ )                                                          | <66> $t_{SDQK}$    | 30                                     |               | 20                                     |               | 15                                     |               | ns   |
| INTP $_n$ low-level width                                                                                       | <67> $t_{PIPL}$    | 80                                     |               | 80                                     |               | 80                                     |               | ns   |
| RxD setup time (vs. SCU internal clock $\downarrow$ )                                                           | <68> $t_{SRX}$     | 500                                    |               | 500                                    |               | 500                                    |               | ns   |

- Notes**
1.  $\overline{MWR}$  and  $\overline{IOWR}$  signals in DMA cycle
  2.  $\overline{MWR}$  and  $\overline{IOWR}$  signals in CPU cycles and  $\overline{BUFEN}$ ,  $\overline{BUFR}/W$ ,  $\overline{INTAK}$  and  $\overline{REFRQ}$  signals.
  3.  $t_{KKH} + 2t_{CYK} - 10$  (Reference value when a 1.1-k $\Omega$  pull-up resistor is connected.)
  4.  $t_{KKH} + 2t_{CYK} - 5$  (Reference value when a 1.1-k $\Omega$  pull-up resistor is connected.)

(1)  $\mu$ PD70208H, 70216H-10/12/16 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 5$  V  $\pm 10\%$ ) (3/3)Output Pin Load Capacitance:  $C_L = 100$  pF

| Parameter                                                                          | Symbol            | $\mu$ PD70208H-10<br>$\mu$ PD70216H-10 |      | $\mu$ PD70208H-12<br>$\mu$ PD70216H-12 |      | $\mu$ PD70208H-16<br>$\mu$ PD70216H-16 |      | Unit |
|------------------------------------------------------------------------------------|-------------------|----------------------------------------|------|----------------------------------------|------|----------------------------------------|------|------|
|                                                                                    |                   | MIN.                                   | MAX. | MIN.                                   | MAX. | MIN.                                   | MAX. |      |
| RxD hold time (vs. SCU internal clock $\downarrow$ )                               | <69> $t_{HRX}$    | 500                                    |      | 500                                    |      | 500                                    |      | ns   |
| CLKOUT $\downarrow$ $\rightarrow$ $\overline{SRDY}$ delay time                     | <70> $t_{DKSR}$   |                                        | 100  |                                        | 100  |                                        | 100  | ns   |
| TOUT1 $\downarrow$ $\rightarrow$ TxD delay time                                    | <71> $t_{DTX}$    |                                        | 200  |                                        | 200  |                                        | 200  | ns   |
| TCTL2 setup time (vs. CLKOUT $\downarrow$ )                                        | <72> $t_{SGK}$    | 40                                     |      | 40                                     |      | 40                                     |      | ns   |
| TCTL2 setup time (vs. TCLK $\uparrow$ )                                            | <73> $t_{SGTK}$   | 40                                     |      | 40                                     |      | 40                                     |      | ns   |
| TCTL2 hold time (vs. CLKOUT $\downarrow$ )                                         | <74> $t_{HKG}$    | 80                                     |      | 80                                     |      | 80                                     |      | ns   |
| TCTL2 hold time (vs. TCLK $\uparrow$ )                                             | <75> $t_{HTKG}$   | 40                                     |      | 40                                     |      | 40                                     |      | ns   |
| TCTL2 high-level width                                                             | <76> $t_{GGH}$    | 40                                     |      | 40                                     |      | 40                                     |      | ns   |
| TCTL2 low-level width                                                              | <77> $t_{GGL}$    | 40                                     |      | 40                                     |      | 40                                     |      | ns   |
| TOUT output delay time (vs. CLKOUT $\downarrow$ )                                  | <78> $t_{DKTO}$   |                                        | 150  |                                        | 150  |                                        | 150  | ns   |
| TOUT output delay time (vs. TCLK $\downarrow$ )                                    | <79> $t_{DTKTO}$  |                                        | 100  |                                        | 100  |                                        | 100  | ns   |
| TOUT output delay time (vs. TCTL2 $\downarrow$ )                                   | <80> $t_{DGTO}$   |                                        | 90   |                                        | 90   |                                        | 90   | ns   |
| TCLK rise time                                                                     | <81> $t_{TKR}$    |                                        | 25   |                                        | 25   |                                        | 25   | ns   |
| TCLK fall time                                                                     | <82> $t_{TKF}$    |                                        | 25   |                                        | 25   |                                        | 25   | ns   |
| TCLK high-level width                                                              | <83> $t_{TKTKH}$  | 45                                     |      | 40                                     |      | 30                                     |      | ns   |
| TCLK low-level width                                                               | <84> $t_{TKTKL}$  | 45                                     |      | 40                                     |      | 30                                     |      | ns   |
| TCLK cycle                                                                         | <85> $t_{CYTK}$   | 100                                    | DC   | 80                                     | DC   | 62.5                                   | DC   | ns   |
| Access interval <sup>Note 1</sup>                                                  | <86> $t_{AI}$     | $2t_{CYK}-40$                          |      | $2t_{CYK}-25$                          |      | $2t_{CYK}-20$                          |      | ns   |
| $\overline{REFRQ}$ delay time (vs. $\overline{MRD}$ $\uparrow$ ) <sup>Note 2</sup> | <87> $t_{DRQHRH}$ | $t_{KKL}-30$                           |      | $t_{KKL}-15$                           |      | $t_{KKL}-10$                           |      | ns   |
| $\overline{RESET}$ pulse width <sup>Note 3</sup>                                   | <88> $t_{WRESL}$  | $4t_{CYK}$                             |      | $4t_{CYK}$                             |      | $4t_{CYK}$                             |      | ns   |

- Notes**
1. Specification to guarantee read/write recovery time for I/O device.
  2. Specification to guarantee that  $\overline{REFRQ}$   $\uparrow$  is always later than  $\overline{MRD}$   $\uparrow$ .  
Only guaranteed when the EREF bit of the SCTL register is 0.
  3. When using internal clock generator by connecting a resonator to the X1 and X2 pins, the oscillation stabilization time must be added at power-ON. Because the oscillation stabilization time varies depending on the characteristics of the resonator and oscillator used, evaluate the oscillation stabilization time with the resonator and oscillator actually used.

(2)  $\mu$ PD70208H, 70216H-20 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 5$  V  $\pm 5\%$ ) (1/3)Output Pin Load Capacitance:  $C_L = 100$  pF

| Parameter                                                                  | Symbol           | $\mu$ PD70208H-20<br>$\mu$ PD70216H-20 |      | Unit |
|----------------------------------------------------------------------------|------------------|----------------------------------------|------|------|
|                                                                            |                  | MIN.                                   | MAX. |      |
| External clock input cycle                                                 | <1> $t_{CYX}$    | 25                                     | DC   | ns   |
| External clock input high-level width ( $V_{KH}=3.0$ V)                    | <2> $t_{XXH}$    | 10                                     |      | ns   |
| External clock input low-level width ( $V_{KL}=1.5$ V)                     | <3> $t_{XXL}$    | 10                                     |      | ns   |
| External clock input rise time ( $1.5 \rightarrow 3.0$ V)                  | <4> $t_{XR}$     |                                        | 5    | ns   |
| External clock input fall time ( $3.0 \rightarrow 1.5$ V)                  | <5> $t_{XF}$     |                                        | 5    | ns   |
| Clock output cycle                                                         | <6> $t_{CYK}$    | 50                                     | DC   | ns   |
| Clock output high-level width ( $V_{OH}=3.0$ V)                            | <7> $t_{KKH}$    | $0.5t_{CYK}-5$                         |      | ns   |
| Clock output low-level width ( $V_{OL}=1.5$ V)                             | <8> $t_{KKL}$    | $0.5t_{CYK}-5$                         |      | ns   |
| Clock output rise time ( $1.5 \rightarrow 3.0$ V)                          | <9> $t_{KR}$     |                                        | 5    | ns   |
| Clock output fall time ( $3.0 \rightarrow 1.5$ V)                          | <10> $t_{KF}$    |                                        | 5    | ns   |
| CLKOUT delay time (vs. external clock)                                     | <11> $t_{DXK}$   |                                        | 20   | ns   |
| Input rise time (except external clock) ( $0.8 \rightarrow 2.2$ V)         | <12> $t_{IR}$    |                                        | 15   | ns   |
| Input fall time (except external clock) ( $2.2 \rightarrow 0.8$ V)         | <13> $t_{IF}$    |                                        | 10   | ns   |
| Output rise time (except CLKOUT) ( $0.8 \rightarrow 2.2$ V)                | <14> $t_{OR}$    |                                        | 10   | ns   |
| Output fall time (except CLKOUT) ( $2.2 \rightarrow 0.8$ V)                | <15> $t_{OF}$    |                                        | 10   | ns   |
| RESET setup time (vs. CLKOUT $\downarrow$ ) <sup>Note 1</sup>              | <16> $t_{SRESK}$ | 20                                     |      | ns   |
| RESET hold time (vs. CLKOUT $\downarrow$ ) <sup>Note 1</sup>               | <17> $t_{HKRES}$ | 10                                     |      | ns   |
| RESOUT output delay time (vs. CLKOUT $\downarrow$ )                        | <18> $t_{DKRES}$ | 5                                      | 25   | ns   |
| READY inactive setup time (vs. CLKOUT $\uparrow$ )                         | <19> $t_{SRYLK}$ | 7                                      |      | ns   |
| READY inactive hold time (vs. CLKOUT $\uparrow$ )                          | <20> $t_{HKRYL}$ | 10                                     |      | ns   |
| READY active setup time (vs. CLKOUT $\uparrow$ )                           | <21> $t_{SRYHK}$ | 7                                      |      | ns   |
| READY active hold time (vs. CLKOUT $\uparrow$ )                            | <22> $t_{HKRYH}$ | 10                                     |      | ns   |
| NMI setup time (vs. CLKOUT $\uparrow$ )                                    | <23> $t_{SNMIK}$ | 10                                     |      | ns   |
| POLL setup time (vs. CLKOUT $\uparrow$ )                                   | <24> $t_{SPOLK}$ | 20                                     |      | ns   |
| Data setup time (vs. CLKOUT $\downarrow$ )                                 | <25> $t_{SDK}$   | 7                                      |      | ns   |
| Data hold time (vs. CLKOUT $\downarrow$ )                                  | <26> $t_{HKD}$   | 5                                      |      | ns   |
| CLKOUT $\rightarrow$ address delay time <sup>Note 2</sup>                  | <27> $t_{DKA}$   | 5                                      | 25   | ns   |
| ★ CLKOUT $\rightarrow$ address hold time                                   | <28> $t_{HKA}$   | 5                                      |      | ns   |
| CLKOUT $\downarrow \rightarrow$ PS delay time                              | <29> $t_{DKP}$   | 5                                      | 30   | ns   |
| CLKOUT $\downarrow \rightarrow$ PS float delay time                        | <30> $t_{FKP}$   | 5                                      | 30   | ns   |
| Address setup time (vs. ASTB $\downarrow$ )                                | <31> $t_{SAST}$  | $t_{KKL}-10$                           |      | ns   |
| CLKOUT $\downarrow \rightarrow$ address float delay time <sup>Note 3</sup> | <32> $t_{FKA}$   | $t_{HKA}$                              | 25   | ns   |
| CLKOUT $\downarrow \rightarrow$ ASTB $\uparrow$ delay time                 | <33> $t_{DKSTH}$ |                                        | 20   | ns   |
| CLKOUT $\uparrow \rightarrow$ ASTB $\downarrow$ delay time                 | <34> $t_{DKSTL}$ |                                        | 20   | ns   |
| ASTB high-level width                                                      | <35> $t_{STST}$  | $t_{KKL}-10$                           |      | ns   |

- Notes**
1. When reset with the minimum pulse width or when guaranteeing the RESOUT output timing.
  2. Specifications also corresponding to the QS0, QS1, and  $\overline{\text{BUSLOCK}}$  signals, and A16/PS0-A19/PS3,  $\overline{\text{UBE}}$ ,  $\overline{\text{BUFEN}}$ ,  $\overline{\text{BUFR/W}}$ ,  $\overline{\text{MRD}}$ ,  $\overline{\text{IORD}}$ ,  $\overline{\text{MWR}}$ ,  $\overline{\text{IOWR}}$ , and BS0-BS2 signals at HLDRQ/HLDAK timing.
  3. Specifications also corresponding to the A16/PS0-A19/PS3,  $\overline{\text{UBE}}$ ,  $\overline{\text{BUFEN}}$ ,  $\overline{\text{BUFR/W}}$ ,  $\overline{\text{MRD}}$ ,  $\overline{\text{IORD}}$ ,  $\overline{\text{MWR}}$ ,  $\overline{\text{IOWR}}$ , and BS0-BS2 signals at HLDRQ/HLDAK timing.

(2)  $\mu$ PD70208H, 70216H-20 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 5$  V  $\pm 5\%$ ) (2/3)Output Pin Load Capacitance:  $C_L = 100$  pF

| Parameter                                                                                                                 | Symbol             | $\mu$ PD70208H-20<br>$\mu$ PD70216H-20 |               | Unit |
|---------------------------------------------------------------------------------------------------------------------------|--------------------|----------------------------------------|---------------|------|
|                                                                                                                           |                    | MIN.                                   | MAX.          |      |
| ASTB $\downarrow \rightarrow$ address hold time                                                                           | <36> $t_{HSTA}$    | $t_{KKH}-10$                           |               | ns   |
| CLKOUT $\rightarrow$ control 1 <sup>Note 1</sup> delay time                                                               | <37> $t_{DKCT1}$   | 5                                      | 25            | ns   |
| CLKOUT $\rightarrow$ control 2 <sup>Note 2</sup> delay time                                                               | <38> $t_{DKCT2}$   | 5                                      | 30            | ns   |
| Address float $\rightarrow \overline{RD} \downarrow$ delay time                                                           | <39> $t_{DAFRL}$   | 0                                      |               | ns   |
| CLKOUT $\downarrow \rightarrow \overline{RD} \downarrow$ delay time                                                       | <40> $t_{DKRL}$    | 5                                      | 25            | ns   |
| CLKOUT $\downarrow \rightarrow \overline{RD} \uparrow$ delay time                                                         | <41> $t_{DKRH}$    | 5                                      | 28            | ns   |
| $\overline{RD} \uparrow \rightarrow$ address delay time                                                                   | <42> $t_{DRHA}$    | $t_{CYK}-5$                            |               | ns   |
| $\overline{RD}$ low-level width                                                                                           | <43> $t_{RR}$      | $2t_{CYK}-15$                          |               | ns   |
| $\overline{BUFEN} \uparrow \rightarrow \overline{BUF\overline{R}/W}$ delay time (read cycle)                              | <44> $t_{DBECT}$   | $t_{KKL}-10$                           |               | ns   |
| CLKOUT $\downarrow \rightarrow$ data output delay time                                                                    | <45> $t_{DKD}$     | 5                                      | 25            | ns   |
| CLKOUT $\downarrow \rightarrow$ data float delay time                                                                     | <46> $t_{FKD}$     | 5                                      | 25            | ns   |
| $\overline{WR}$ low-level width                                                                                           | <47> $t_{WW}$      | $2t_{CYK}-15$                          |               | ns   |
| $\overline{WR} \uparrow \rightarrow \overline{BUFEN} \uparrow$ or $\overline{BUF\overline{R}/W} \downarrow$ (write cycle) | <48> $t_{DWCT}$    | $t_{KKL}-10$                           |               | ns   |
| CLKOUT $\uparrow \rightarrow BS \downarrow$ delay time                                                                    | <49> $t_{DKBL}$    | 5                                      | 30            | ns   |
| CLKOUT $\downarrow \rightarrow BS \uparrow$ delay time                                                                    | <50> $t_{DKBH}$    | 5                                      | 25            | ns   |
| HLD $\overline{RQ}$ setup time (vs. CLKOUT $\downarrow$ )                                                                 | <51> $t_{SHQK}$    | 7                                      |               | ns   |
| CLKOUT $\downarrow \rightarrow$ HLD $\overline{AK}$ delay time                                                            | <52> $t_{DKHA}$    | 5                                      | 25            | ns   |
| CLKOUT $\uparrow \rightarrow \overline{DMAAK}$ delay time                                                                 | <53> $t_{DKHDA}$   | 5                                      | 25            | ns   |
| CLKOUT $\downarrow \rightarrow \overline{DMAAK}$ delay time (cascade mode)                                                | <54> $t_{DKLDA}$   | 5                                      | 45            | ns   |
| $\overline{WR}$ low-level width (DMA cycle)                                                                               | DMA extended write | <55> $t_{WW1}$                         | $2t_{CYK}-15$ | ns   |
|                                                                                                                           | DMA normal write   | <56> $t_{WW2}$                         | $t_{CYK}-15$  | ns   |
| $\overline{RD} \downarrow, \overline{WR} \downarrow$ delay time (vs. $\overline{DMAAK} \downarrow$ )                      | <57> $t_{DDARW}$   | $t_{KKH}-10$                           |               | ns   |
| $\overline{DMAAK} \uparrow$ delay time (vs. $\overline{RD} \uparrow$ )                                                    | <58> $t_{DRHDAH}$  | $t_{KKL}-10$                           |               | ns   |
| $\overline{RD} \uparrow$ delay time (vs. $\overline{WR} \uparrow$ )                                                       | <59> $t_{DWHRH}$   | 3                                      |               | ns   |
| $\overline{TC}$ output delay time (vs. CLKOUT $\uparrow$ )                                                                | <60> $t_{DKTCL}$   |                                        | 25            | ns   |
| $\overline{TC}$ OFF delay time (vs. CLKOUT $\uparrow$ )                                                                   | <61> $t_{DKTCF}$   |                                        | 25            | ns   |
| $\overline{TC}$ low-level width                                                                                           | <62> $t_{TCTCL}$   | $t_{CYK}-10$                           |               | ns   |
| $\overline{TC}$ pull-up delay time (vs. CLKOUT $\uparrow$ )                                                               | <63> $t_{DKTCH}$   |                                        | Note 3        | ns   |
| $\overline{END}$ setup time (vs. CLKOUT $\uparrow$ )                                                                      | <64> $t_{SEDK}$    | 20                                     |               | ns   |
| $\overline{END}$ low-level width                                                                                          | <65> $t_{EDEDL}$   | 40                                     |               | ns   |
| DMARQ setup time (vs. CLKOUT $\uparrow$ )                                                                                 | <66> $t_{SDQK}$    | 10                                     |               | ns   |
| INTP $_n$ low-level width                                                                                                 | <67> $t_{PIPL}$    | 60                                     |               | ns   |
| RxD setup time (vs. SCU internal clock $\downarrow$ )                                                                     | <68> $t_{SRX}$     | 500                                    |               | ns   |
| RxD hold time (vs. SCU internal clock $\downarrow$ )                                                                      | <69> $t_{HRX}$     | 500                                    |               | ns   |
| CLKOUT $\downarrow \rightarrow \overline{SRD\overline{Y}}$ delay time                                                     | <70> $t_{DKSR}$    |                                        | 100           | ns   |

- Notes**
1.  $\overline{MWR}$  and  $\overline{IOWR}$  signals in DMA cycle
  2.  $\overline{MWR}$  and  $\overline{IOWR}$  signals in  $\overline{BUFEN}$ ,  $\overline{BUF\overline{R}/W}$ ,  $\overline{INTAK}$ ,  $\overline{REFRQ}$ , and CPU cycles
  3.  $t_{KKH} + 2t_{CYK} - 5$  (reference value when a 1.1-k $\Omega$  pull-up resistor is connected)

(2)  $\mu$ PD70208H, 70216H-20 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 5$  V  $\pm 5\%$ ) (3/3)Output Pin Load Capacitance:  $C_L = 100$  pF

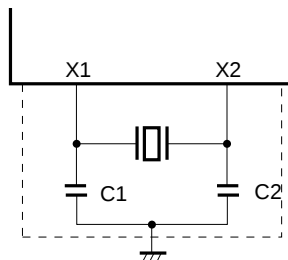
| Parameter                                                                                                   | Symbol            | $\mu$ PD70208H-20<br>$\mu$ PD70216H-20 |      | Unit |
|-------------------------------------------------------------------------------------------------------------|-------------------|----------------------------------------|------|------|
|                                                                                                             |                   | MIN.                                   | MAX. |      |
| TOUT1 $\downarrow \rightarrow$ TxD delay time                                                               | <71> $t_{DTX}$    |                                        | 200  | ns   |
| TCTL2 setup time (vs. CLKOUT $\downarrow$ )                                                                 | <72> $t_{SGK}$    | 40                                     |      | ns   |
| TCTL2 setup time (vs. TCLK $\uparrow$ )                                                                     | <73> $t_{SGTK}$   | 40                                     |      | ns   |
| TCTL2 hold time (vs. CLKOUT $\downarrow$ )                                                                  | <74> $t_{HKG}$    | 80                                     |      | ns   |
| TCTL2 hold time (vs. TCLK $\uparrow$ )                                                                      | <75> $t_{HTKG}$   | 40                                     |      | ns   |
| TCTL2 high-level width                                                                                      | <76> $t_{GGH}$    | 40                                     |      | ns   |
| TCTL2 low-level width                                                                                       | <77> $t_{GGL}$    | 40                                     |      | ns   |
| TOUT output delay time (vs. CLKOUT $\downarrow$ )                                                           | <78> $t_{DKTO}$   |                                        | 150  | ns   |
| TOUT output delay time (vs. TCLK $\downarrow$ )                                                             | <79> $t_{DTKTO}$  |                                        | 100  | ns   |
| TOUT output delay time (vs. TCTL2 $\downarrow$ )                                                            | <80> $t_{DGTO}$   |                                        | 90   | ns   |
| TCLK rise time                                                                                              | <81> $t_{TKR}$    |                                        | 25   | ns   |
| TCLK fall time                                                                                              | <82> $t_{TKF}$    |                                        | 25   | ns   |
| TCLK high-level width                                                                                       | <83> $t_{TKTKH}$  | 23                                     |      | ns   |
| TCLK low-level width                                                                                        | <84> $t_{TKTKL}$  | 23                                     |      | ns   |
| TCLK cycle                                                                                                  | <85> $t_{CYTK}$   | 50                                     | DC   | ns   |
| Access interval <sup>Note 1</sup>                                                                           | <86> $t_{AI}$     | $2t_{CYK}-15$                          |      | ns   |
| $\overline{\text{REFRQ}}$ $\uparrow$ delay time (vs. $\overline{\text{MRD}}$ $\uparrow$ ) <sup>Note 2</sup> | <87> $t_{DRQHRH}$ | $t_{KKL}-10$                           |      | ns   |
| $\overline{\text{RESET}}$ pulse width <sup>Note 3</sup>                                                     | <88> $t_{WRESL}$  | $4t_{CYK}$                             |      | ns   |

- Notes**
1. This rating is to guarantee the read/write recovery time for the I/O device.
  2. This rating is to guarantee that  $\overline{\text{REFRQ}}$   $\uparrow$  is always behind  $\overline{\text{MRD}}$   $\uparrow$ , and guaranteed only when the EREF bit of the STCL register is 0.
  3. When using internal clock generator by connecting a resonator to the X1 and X2 pins, the oscillation stabilization time must be added at power-ON. Because the oscillation stabilization time varies depending on the characteristics of the resonator and oscillator used, evaluate the oscillation stabilization time with the resonator and oscillator actually used.

# RECOMMENDED OSCILLATOR

The clock input circuits (1) and (2) shown below are recommended.

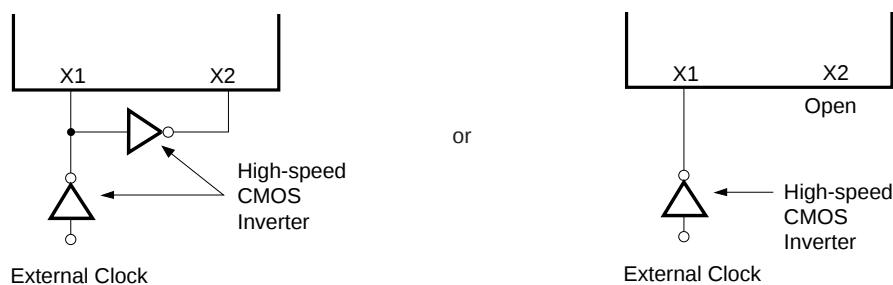
- (1) Ceramic resonator connection ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 5$  V  $\pm 10\%$  (μPD70208H, 70216H-10/12/16),  $V_{DD} = 5$  V  $\pm 5\%$  (μPD70208H, 70216H-20))



- Cautions**
1. The oscillator should be as close as possible to the X1 and X2 pins.
  2. No other signal lines should pass through the area enclosed in dashed line.
  3. For matching between V40HL, V50HL and resonator, the efficient evaluation should be carried out.
  4. The values of the oscillator constants C1 and C2 depend on the characteristics of the resonator used. Evaluate them with the resonator actually used.

| Manufacturer          | Frequency (f <sub>xx</sub> ) [MHz] | Product Name   | Recommended Constant |         |
|-----------------------|------------------------------------|----------------|----------------------|---------|
|                       |                                    |                | C1 [pF]              | C2 [pF] |
| Murata Mfg. Co., Ltd. | 40                                 | CSA40.00MXZ040 | 3                    | 3       |
|                       | 32                                 | CSA32.00MXZ040 | 5                    | 5       |
|                       | 25                                 | CSA25.00MXZ040 | 5                    | 5       |
|                       | 20                                 | CSA20.00MXZ040 | 10                   | 10      |
| TDK Corp.             | 32                                 | FCR32.0M2G     | 5                    | 5       |
|                       | 25                                 | FCR25.0M2G     | 5                    | 5       |
|                       | 20                                 | FCR20.0M2G     | 10                   | 10      |

## (2) External clock input



**Caution** The high-speed CMOS inverter should be as close as possible to the X1 and X2 pins.

## 16.2 AT 3 V OPERATION

## OPERATING RANGE

|                                 | E, P, X, M Masks               | Others                         |
|---------------------------------|--------------------------------|--------------------------------|
| $\mu$ PD70208H, 70216H-10/12/16 | $V_{DD} = 3\text{ V} \pm 10\%$ |                                |
| $\mu$ PD70208H, 70216H-20       | —                              | $V_{DD} = 3\text{ V} \pm 10\%$ |

ABSOLUTE MAXIMUM RATINGS ( $T_A = 25\text{ }^{\circ}\text{C}$ )

| Parameter                     | Symbol    | Test Conditions                | Rating                 | Unit               |
|-------------------------------|-----------|--------------------------------|------------------------|--------------------|
| Supply voltage                | $V_{DD}$  |                                | −0.5 to +7.0           | V                  |
| Input voltage                 | $V_I$     | $V_{DD} = 3\text{ V} \pm 10\%$ | −0.5 to $V_{DD} + 0.3$ | V                  |
| Clock input voltage           | $V_K$     |                                | −0.5 to $V_{DD} + 1.0$ | V                  |
| Output voltage                | $V_O$     |                                | −0.5 to $V_{DD} + 0.3$ | V                  |
| Operating ambient temperature | $T_A$     |                                | −40 to +85             | $^{\circ}\text{C}$ |
| Storage temperature           | $T_{stg}$ |                                | −65 to +150            | $^{\circ}\text{C}$ |

- Cautions**
1. Do not directly connect the output pins of two or more IC products and do not directly connect the output pins to  $V_{DD}$  or  $V_{CC}$  and GND. However, open-drain pins or open-collector pins may be connected directly. Moreover, an external circuit whose timing is designed to avoid output collision can be connected to pins that go into a high-impedance state.
  2. If even one of the above parameters exceeds the absolute maximum rating even momentarily, the quality of the program may be degraded. Absolute maximum ratings, therefore, are the values exceeding which the product may be physically damaged. Use the program keeping all the parameters within these rated values.

The standards and conditions shown in DC and AC Characteristics below specify the range within which the normal operation of the product is guaranteed.

**DC CHARACTERISTICS** ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 3$  V  $\pm 10\%$ )

| Parameter                       | Symbol            | Test Conditions                                              |                   | MIN.                  | TYP.               | MAX.                 | Unit |
|---------------------------------|-------------------|--------------------------------------------------------------|-------------------|-----------------------|--------------------|----------------------|------|
| Input voltage high              | V <sub>IH</sub>   | Except $\overline{\text{RESET}}$                             |                   | 0.7 V <sub>DD</sub>   |                    | V <sub>DD</sub> +0.3 | V    |
|                                 |                   | $\overline{\text{RESET}}$                                    |                   | 0.8 V <sub>DD</sub>   |                    | V <sub>DD</sub> +0.3 |      |
| Input voltage low               | V <sub>IL</sub>   | Except $\overline{\text{RESET}}$                             |                   | −0.5                  |                    | 0.2 V <sub>DD</sub>  | V    |
|                                 |                   | $\overline{\text{RESET}}$                                    |                   |                       |                    |                      |      |
| Clock input voltage high        | V <sub>KH</sub>   |                                                              |                   | 0.8 V <sub>DD</sub>   |                    | V <sub>DD</sub> +0.5 | V    |
| Clock input voltage low         | V <sub>KL</sub>   |                                                              |                   | −0.5                  |                    | 0.2 V <sub>DD</sub>  | V    |
| Output voltage high             | V <sub>OH</sub>   | I <sub>OH</sub> = −2.5 mA                                    |                   | 0.7 V <sub>DD</sub>   |                    |                      | V    |
|                                 |                   | I <sub>OH</sub> = −100 μA                                    |                   | V <sub>DD</sub> − 0.4 |                    |                      |      |
| Output voltage low              | V <sub>OL</sub>   | Except $\overline{\text{END/TC}}$ : I <sub>OL</sub> = 2.5 mA |                   |                       |                    | 0.4                  | V    |
|                                 |                   | $\overline{\text{END/TC}}$ : I <sub>OL</sub> = 5.0 mA        |                   |                       |                    |                      |      |
| Input leak current high         | I <sub>LIH</sub>  | V <sub>I</sub> = V <sub>DD</sub>                             |                   |                       |                    | 10                   | μA   |
| Input leak current low          | I <sub>LIL</sub>  | V <sub>I</sub> = 0 V : Except INTP                           |                   |                       |                    | −10                  | μA   |
| INTP input current low          | I <sub>LIPL</sub> | V <sub>I</sub> = 0 V : INTP input                            |                   |                       |                    | −300                 | μA   |
| Output leak current high        | I <sub>LOH</sub>  | V <sub>O</sub> = V <sub>DD</sub>                             |                   |                       |                    | 10                   | μA   |
| Output leak current low         | I <sub>LOL</sub>  | V <sub>O</sub> = 0 V                                         |                   |                       |                    | −10                  | μA   |
| Latch leak current high         | I <sub>LLH</sub>  | V <sub>I</sub> = 3.0 V                                       |                   | −50                   |                    | −300                 | μA   |
| Latch leak current low          | I <sub>LLL</sub>  | V <sub>I</sub> = 0.8 V                                       |                   | 50                    |                    | 300                  | μA   |
| Latch inversion current (L → H) | I <sub>ILH</sub>  |                                                              |                   |                       |                    | 400                  | μA   |
| Latch inversion current (H → L) | I <sub>ILL</sub>  |                                                              |                   |                       |                    | −400                 | μA   |
| Supply current <sup>Note</sup>  | I <sub>DD</sub>   | E, P, X, M masks                                             | On Operation      |                       | 3.0 f <sub>x</sub> | 5.5 f <sub>x</sub>   | mA   |
|                                 |                   |                                                              | On standby (HALT) |                       | 0.9 f <sub>x</sub> | 1.5 f <sub>x</sub>   |      |
|                                 |                   |                                                              | On standby (STOP) |                       |                    | 30                   | μA   |
|                                 |                   | Others                                                       | On Operation      |                       | 2.5 f <sub>x</sub> | 4.0 f <sub>x</sub>   | mA   |
|                                 |                   |                                                              | On standby (HALT) |                       | 0.9 f <sub>x</sub> | 1.5 f <sub>x</sub>   |      |
|                                 |                   |                                                              | On standby (STOP) |                       |                    | 30                   | μA   |

**Note** The unit of constant values (0.9, 1.5, 2.5, 3.0, 4.0 and 5.5) is mA/MHz.

**CAPACITANCE** ( $T_A = 25$  °C,  $V_{DD} = 0$  V)

| Parameter                | Symbol   | Test Conditions          | MIN. | TYP. | MAX. | Unit |
|--------------------------|----------|--------------------------|------|------|------|------|
| Input capacitance        | $C_I$    | $f_c = 1$ MHz            |      |      | 10   | pF   |
| Input/output capacitance | $C_{IO}$ | 0 V other than test pin. |      |      | 15   | pF   |

## AC CHARACTERISTICS

(1)  $\mu$ PD70208H, 70216H-10/12/16 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 3$  V  $\pm 10\%$ ) (1/3)Output Pin Load Capacitance:  $C_L = 100$  pF

| Parameter                                                                       | Symbol |             | $\mu$ PD70208H-10<br>$\mu$ PD70216H-10 |      | $\mu$ PD70208H-12<br>$\mu$ PD70216H-12 |      | $\mu$ PD70208H-16<br>$\mu$ PD70216H-16 |      | Unit |
|---------------------------------------------------------------------------------|--------|-------------|----------------------------------------|------|----------------------------------------|------|----------------------------------------|------|------|
|                                                                                 |        |             | MIN.                                   | MAX. | MIN.                                   | MAX. | MIN.                                   | MAX. |      |
| External clock input cycle                                                      | <1>    | $t_{CYX}$   | 100                                    | DC   | 83                                     | DC   | 62.5                                   | DC   | ns   |
| External clock input high-level width ( $V_{KH}=0.8 V_{DD}$ )                   | <2>    | $t_{XXH}$   | 40                                     |      | 30                                     |      | 20                                     |      | ns   |
| External clock input low-level width ( $V_{KL}=0.2 V_{DD}$ )                    | <3>    | $t_{XXL}$   | 40                                     |      | 30                                     |      | 20                                     |      | ns   |
| External clock input rise time ( $0.2 V_{DD} \rightarrow 0.8 V_{DD}$ )          | <4>    | $t_{XR}$    |                                        | 10   |                                        | 10   |                                        | 10   | ns   |
| External clock input fall time ( $0.8 V_{DD} \rightarrow 0.2 V_{DD}$ )          | <5>    | $t_{XF}$    |                                        | 10   |                                        | 10   |                                        | 10   | ns   |
| Clock output cycle                                                              | <6>    | $t_{CYK}$   | 200                                    | DC   | 166                                    | DC   | 125                                    | DC   | ns   |
| Clock output high-level width ( $V_{OH}=0.7 V_{DD}$ )                           | <7>    | $t_{KXH}$   | $0.5t_{CYK}-7$                         |      | $0.5t_{CYK}-7$                         |      | $0.5t_{CYK}-7$                         |      | ns   |
| Clock output low-level width ( $V_{OL}=0.2 V_{DD}$ )                            | <8>    | $t_{KXL}$   | $0.5t_{CYK}-7$                         |      | $0.5t_{CYK}-7$                         |      | $0.5t_{CYK}-7$                         |      | ns   |
| Clock output rise time ( $0.2 V_{DD} \rightarrow 0.7 V_{DD}$ )                  | <9>    | $t_{KR}$    |                                        | 7    |                                        | 7    |                                        | 7    | ns   |
| Clock output fall time ( $0.7 V_{DD} \rightarrow 0.2 V_{DD}$ )                  | <10>   | $t_{KF}$    |                                        | 7    |                                        | 7    |                                        | 7    | ns   |
| CLKOUT delay time (vs. external clock)                                          | <11>   | $t_{DXK}$   |                                        | 75   |                                        | 65   |                                        | 55   | ns   |
| Input rise time (except external clock) ( $0.2 V_{DD} \rightarrow 0.7 V_{DD}$ ) | <12>   | $t_{IR}$    |                                        | 20   |                                        | 20   |                                        | 20   | ns   |
| Input fall time (except external clock) ( $0.7 V_{DD} \rightarrow 0.2 V_{DD}$ ) | <13>   | $t_{IF}$    |                                        | 12   |                                        | 12   |                                        | 12   | ns   |
| Output rise time (except CLKOUT) ( $0.2 V_{DD} \rightarrow 0.7 V_{DD}$ )        | <14>   | $t_{OR}$    |                                        | 20   |                                        | 20   |                                        | 20   | ns   |
| Output fall time (except CLKOUT) ( $0.7 V_{DD} \rightarrow 0.2 V_{DD}$ )        | <15>   | $t_{OF}$    |                                        | 12   |                                        | 12   |                                        | 12   | ns   |
| RESET setup time (vs. CLKOUT↓) <b>Note 1</b>                                    | <16>   | $t_{SRESK}$ | 25                                     |      | 25                                     |      | 25                                     |      | ns   |
| RESET hold time (vs. CLKOUT↓) <b>Note 1</b>                                     | <17>   | $t_{HKRES}$ | 35                                     |      | 35                                     |      | 35                                     |      | ns   |
| RESOUT output delay time (vs. CLKOUT↓)                                          | <18>   | $t_{DKRES}$ | 5                                      | 80   | 5                                      | 70   | 5                                      | 60   | ns   |
| READY inactive setup time (vs. CLKOUT↑)                                         | <19>   | $t_{SRYLK}$ | 20                                     |      | 20                                     |      | 15                                     |      | ns   |
| READY inactive hold time (vs. CLKOUT↑)                                          | <20>   | $t_{HKRYL}$ | 30                                     |      | 30                                     |      | 25                                     |      | ns   |
| READY active setup time (vs. CLKOUT↑)                                           | <21>   | $t_{SRYHK}$ | 20                                     |      | 20                                     |      | 15                                     |      | ns   |
| READY active hold time (vs. CLKOUT↑)                                            | <22>   | $t_{HKRYH}$ | 30                                     |      | 30                                     |      | 25                                     |      | ns   |
| NMI setup time (vs. CLKOUT↑)                                                    | <23>   | $t_{SNMIK}$ | 15                                     |      | 15                                     |      | 15                                     |      | ns   |
| POLL setup time (vs. CLKOUT↑)                                                   | <24>   | $t_{SPOLK}$ | 20                                     |      | 20                                     |      | 20                                     |      | ns   |
| Data setup time (vs. CLKOUT↓)                                                   | <25>   | $t_{SDK}$   | 20                                     |      | 20                                     |      | 15                                     |      | ns   |
| Data hold time (vs. CLKOUT↓)                                                    | <26>   | $t_{HKD}$   | 5                                      |      | 5                                      |      | 5                                      |      | ns   |
| CLKOUT → address delay time <b>Note 2</b>                                       | <27>   | $t_{DKA}$   | 5                                      | 75   | 5                                      | 65   | 5                                      | 55   | ns   |
| ★ CLKOUT → address hold time                                                    | <28>   | $t_{HKA}$   | 5                                      |      | 5                                      |      | 5                                      |      | ns   |
| CLKOUT↓ → PS delay time                                                         | <29>   | $t_{DKP}$   | 5                                      | 80   | 5                                      | 70   | 5                                      | 60   | ns   |
| CLKOUT↓ → PS float delay time                                                   | <30>   | $t_{FKP}$   | 5                                      | 80   | 5                                      | 70   | 5                                      | 60   | ns   |
| Address setup time (vs. ASTB↓)                                                  | <31>   | $t_{SAST}$  | $t_{KKL}-30$                           |      | $t_{KKL}-30$                           |      | $t_{KKL}-30$                           |      | ns   |
| CLKOUT↓ → address float delay time <b>Note 3</b>                                | <32>   | $t_{FKA}$   | 5                                      | 80   | 5                                      | 70   | 5                                      | 60   | ns   |
| CLKOUT↓ → ASTB↑ delay time                                                      | <33>   | $t_{DKSTH}$ | 5                                      | 65   | 5                                      | 55   | 5                                      | 45   | ns   |
| CLKOUT↑ → ASTB↓ delay time                                                      | <34>   | $t_{DKSTL}$ | 5                                      | 70   | 5                                      | 60   | 5                                      | 50   | ns   |
| ASTB high-level width                                                           | <35>   | $t_{STST}$  | $t_{KKL}-10$                           |      | $t_{KKL}-10$                           |      | $t_{KKL}-10$                           |      | ns   |

**Notes** 1. When reset with the minimum pulse width or when guaranteeing the RESOUT output timing.2. Specifications also corresponding to the QS0, QS1, and BUSLOCK signals, and A16/PS0-A19/PS3,  $\overline{UBE}$ ,  $\overline{BUFEN}$ ,  $\overline{BUFR}/W$ ,  $\overline{MRD}$ ,  $\overline{IORD}$ ,  $\overline{MWR}$ ,  $\overline{IOWR}$ , and BS0-BS2 signals at HLDRQ/HLDAK timing.3. Specifications also corresponding to the A16/PS0-A19/PS3,  $\overline{UBE}$ ,  $\overline{BUFEN}$ ,  $\overline{BUFR}/W$ ,  $\overline{MRD}$ ,  $\overline{IORD}$ ,  $\overline{MWR}$ ,  $\overline{IOWR}$ , and BS0-BS2 signals at HLDRQ/HLDAK timing.

(1)  $\mu$ PD70208H, 70216H-10/12/16 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 3$  V  $\pm 10\%$ ) (2/3)Output Pin Load Capacitance:  $C_L = 100$  pF

| Parameter                                                                                                      | Symbol             | $\mu$ PD70208H-10<br>$\mu$ PD70216H-10 |               | $\mu$ PD70208H-12<br>$\mu$ PD70216H-12 |        | $\mu$ PD70208H-16<br>$\mu$ PD70216H-16 |        | Unit |
|----------------------------------------------------------------------------------------------------------------|--------------------|----------------------------------------|---------------|----------------------------------------|--------|----------------------------------------|--------|------|
|                                                                                                                |                    | MIN.                                   | MAX.          | MIN.                                   | MAX.   | MIN.                                   | MAX.   |      |
| ASTB $\downarrow$ → address hold time                                                                          | <36> $t_{HSTA}$    | $t_{KKH}-30$                           |               | $t_{KKH}-30$                           |        | $t_{KKH}-20$                           |        | ns   |
| CLKOUT → control 1 <sup>Note 1</sup> delay time                                                                | <37> $t_{DKCT1}$   | 5                                      | 90            | 5                                      | 80     | 5                                      | 70     | ns   |
| CLKOUT → control 2 <sup>Note 2</sup> delay time                                                                | <38> $t_{DKCT2}$   | 5                                      | 80            | 5                                      | 70     | 5                                      | 60     | ns   |
| Address float → $\overline{RD}\downarrow$ delay time                                                           | <39> $t_{DAFRL}$   | 0                                      |               | 0                                      |        | 0                                      |        | ns   |
| CLKOUT $\downarrow$ → $\overline{RD}\downarrow$ delay time                                                     | <40> $t_{DKRL}$    | 5                                      | 95            | 5                                      | 85     | 5                                      | 75     | ns   |
| CLKOUT $\downarrow$ → $\overline{RD}\uparrow$ delay time                                                       | <41> $t_{DKRH}$    | 5                                      | 90            | 5                                      | 80     | 5                                      | 70     | ns   |
| $\overline{RD}\uparrow$ → address delay time                                                                   | <42> $t_{DRHA}$    | $t_{CYK}-70$                           |               | $t_{CYK}-60$                           |        | $t_{CYK}-50$                           |        | ns   |
| $\overline{RD}$ low-level width                                                                                | <43> $t_{RR}$      | $2t_{CYK}-70$                          |               | $2t_{CYK}-60$                          |        | $2t_{CYK}-50$                          |        | ns   |
| $\overline{BUFEN}\uparrow$ → $\overline{BUF}\overline{R}/W$ delay time (read cycle)                            | <44> $t_{DBECT}$   | $t_{KKL}-30$                           |               | $t_{KKL}-30$                           |        | $t_{KKL}-20$                           |        | ns   |
| CLKOUT $\downarrow$ → data output delay time                                                                   | <45> $t_{DKD}$     | 5                                      | 80            | 5                                      | 70     | 5                                      | 60     | ns   |
| CLKOUT $\downarrow$ → data float delay time                                                                    | <46> $t_{FKD}$     | 5                                      | 80            | 5                                      | 70     | 5                                      | 60     | ns   |
| $\overline{WR}$ low-level width                                                                                | <47> $t_{WW}$      | $2t_{CYK}-50$                          |               | $2t_{CYK}-50$                          |        | $2t_{CYK}-40$                          |        | ns   |
| $\overline{WR}\uparrow$ → $\overline{BUFEN}\uparrow$ or $\overline{BUF}\overline{R}/W\downarrow$ (write cycle) | <48> $t_{DWCT}$    | $t_{KKL}-30$                           |               | $t_{KKL}-30$                           |        | $t_{KKL}-20$                           |        | ns   |
| CLKOUT $\uparrow$ → BS $\downarrow$ delay time                                                                 | <49> $t_{DKBL}$    | 5                                      | 80            | 5                                      | 70     | 5                                      | 60     | ns   |
| CLKOUT $\downarrow$ → BS $\uparrow$ delay time                                                                 | <50> $t_{DKBH}$    | 5                                      | 80            | 5                                      | 70     | 5                                      | 60     | ns   |
| HLD $\overline{RQ}$ setup time (vs. CLKOUT $\downarrow$ )                                                      | <51> $t_{SHQK}$    | 25                                     |               | 25                                     |        | 20                                     |        | ns   |
| CLKOUT $\downarrow$ → HLD $\overline{AK}$ delay time                                                           | <52> $t_{DKHA}$    | 5                                      | 90            | 5                                      | 80     | 5                                      | 70     | ns   |
| CLKOUT $\uparrow$ → $\overline{DMAAK}\downarrow$ delay time                                                    | <53> $t_{DKHDA}$   | 5                                      | 80            | 5                                      | 70     | 5                                      | 60     | ns   |
| CLKOUT $\downarrow$ → $\overline{DMAAK}\downarrow$ delay time (cascade mode)                                   | <54> $t_{DKLDA}$   | 5                                      | 110           | 5                                      | 100    | 5                                      | 90     | ns   |
| $\overline{WR}$ low-level width<br>(DMA cycle)                                                                 | DMA extended write | <55> $t_{WW1}$                         | $2t_{CYK}-50$ | $2t_{CYK}-50$                          |        | $2t_{CYK}-40$                          |        | ns   |
|                                                                                                                | DMA normal write   | <56> $t_{WW2}$                         | $t_{CYK}-50$  | $t_{CYK}-50$                           |        | $t_{CYK}-40$                           |        | ns   |
| $\overline{RD}\downarrow$ $\overline{WR}\downarrow$ delay time (vs. $\overline{DMAAK}\downarrow$ )             | <57> $t_{DDARW}$   | $t_{KKH}-40$                           |               | $t_{KKH}-40$                           |        | $t_{KKH}-30$                           |        | ns   |
| $\overline{DMAAK}\uparrow$ delay time (vs. $\overline{RD}\uparrow$ )                                           | <58> $t_{DRHDAH}$  | $t_{KKL}-40$                           |               | $t_{KKL}-40$                           |        | $t_{KKL}-30$                           |        | ns   |
| $\overline{RD}\uparrow$ delay time (vs. $\overline{WR}\uparrow$ )                                              | <59> $t_{DWHRH}$   | 5                                      |               | 5                                      |        | 5                                      |        | ns   |
| $\overline{TC}$ output delay time (vs. CLKOUT $\uparrow$ )                                                     | <60> $t_{DKTCL}$   | 5                                      | 80            | 5                                      | 70     | 5                                      | 60     | ns   |
| $\overline{TC}$ OFF delay time (vs. CLKOUT $\uparrow$ )                                                        | <61> $t_{DKTCF}$   | 5                                      | 80            | 5                                      | 70     | 5                                      | 60     | ns   |
| $\overline{TC}$ low-level width                                                                                | <62> $t_{TCTCL}$   | $t_{CYK}-25$                           |               | $t_{CYK}-25$                           |        | $t_{CYK}-15$                           |        | ns   |
| $\overline{TC}$ pull-up delay time (vs. CLKOUT $\uparrow$ )                                                    | <63> $t_{DKTCH}$   |                                        | Note 3        |                                        | Note 4 |                                        | Note 4 | ns   |
| $\overline{END}$ setup time (vs. CLKOUT $\uparrow$ )                                                           | <64> $t_{SEDK}$    | 45                                     |               | 40                                     |        | 35                                     |        | ns   |
| $\overline{END}$ low-level width                                                                               | <65> $t_{EDEDL}$   | 140                                    |               | 120                                    |        | 100                                    |        | ns   |
| DMARQ setup time (vs. CLKOUT $\uparrow$ )                                                                      | <66> $t_{SDQK}$    | 45                                     |               | 40                                     |        | 35                                     |        | ns   |
| INTPn low-level width                                                                                          | <67> $t_{IPIPL}$   | 100                                    |               | 100                                    |        | 100                                    |        | ns   |
| RxD setup time (vs. SCU internal clock $\downarrow$ )                                                          | <68> $t_{SRX}$     | 1000                                   |               | 1000                                   |        | 1000                                   |        | ns   |
| RxD hold time (vs. SCU internal clock $\downarrow$ )                                                           | <69> $t_{HRX}$     | 1000                                   |               | 1000                                   |        | 1000                                   |        | ns   |
| CLKOUT $\downarrow$ → $\overline{SRDY}$ delay time                                                             | <70> $t_{DKSR}$    |                                        | 150           |                                        | 150    |                                        | 150    | ns   |

**Notes** 1.  $\overline{MWR}$  and  $\overline{IOWR}$  signals in DMA cycle2.  $\overline{MWR}$  and  $\overline{IOWR}$  signals in CPU cycles and  $\overline{BUFEN}$ ,  $\overline{BUF}\overline{R}/W$ ,  $\overline{INTAK}$  and  $\overline{REFRQ}$  signals.3.  $t_{KKH} + 2t_{CYK} - 20$  (Reference value when a 1.1-k $\Omega$  pull-up resistor is connected)4.  $t_{KKH} + 2t_{CYK} - 10$  (Reference value when a 1.1-k $\Omega$  pull-up resistor is connected)

(1)  $\mu$ PD70208H, 70216H-10/12/16 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 3$  V  $\pm 10\%$ ) (3/3)Output Pin Load Capacitance:  $C_L = 100$  pF

| Parameter                                                                                             | Symbol            | $\mu$ PD70208H-10<br>$\mu$ PD70216H-10 |      | $\mu$ PD70208H-12<br>$\mu$ PD70216H-12 |      | $\mu$ PD70208H-16<br>$\mu$ PD70216H-16 |      | Unit |
|-------------------------------------------------------------------------------------------------------|-------------------|----------------------------------------|------|----------------------------------------|------|----------------------------------------|------|------|
|                                                                                                       |                   | MIN.                                   | MAX. | MIN.                                   | MAX. | MIN.                                   | MAX. |      |
| TOUT1 $\downarrow$ $\rightarrow$ TxD delay time                                                       | <71> $t_{DTX}$    |                                        | 500  |                                        | 500  |                                        | 500  | ns   |
| TCTL2 setup time (vs. CLKOUT $\downarrow$ )                                                           | <72> $t_{SGK}$    | 50                                     |      | 50                                     |      | 50                                     |      | ns   |
| TCTL2 setup time (vs. TCLK $\uparrow$ )                                                               | <73> $t_{SGTK}$   | 50                                     |      | 50                                     |      | 50                                     |      | ns   |
| TCTL2 hold time (vs. CLKOUT $\downarrow$ )                                                            | <74> $t_{HKG}$    | 100                                    |      | 100                                    |      | 100                                    |      | ns   |
| TCTL2 hold time (vs. TCLK $\uparrow$ )                                                                | <75> $t_{HTKG}$   | 50                                     |      | 50                                     |      | 50                                     |      | ns   |
| TCTL2 high-level width                                                                                | <76> $t_{GGH}$    | 50                                     |      | 50                                     |      | 50                                     |      | ns   |
| TCTL2 low-level width                                                                                 | <77> $t_{GGL}$    | 50                                     |      | 50                                     |      | 50                                     |      | ns   |
| TOUT output delay time (vs. CLKOUT $\downarrow$ )                                                     | <78> $t_{DKTO}$   |                                        | 200  |                                        | 200  |                                        | 200  | ns   |
| TOUT output delay time (vs. TCLK $\downarrow$ )                                                       | <79> $t_{DTKTO}$  |                                        | 150  |                                        | 150  |                                        | 150  | ns   |
| TOUT output delay time (vs. TCTL2 $\downarrow$ )                                                      | <80> $t_{DGTO}$   |                                        | 120  |                                        | 120  |                                        | 120  | ns   |
| TCLK rise time                                                                                        | <81> $t_{TKR}$    |                                        | 25   |                                        | 25   |                                        | 25   | ns   |
| TCLK fall time                                                                                        | <82> $t_{TKF}$    |                                        | 25   |                                        | 25   |                                        | 25   | ns   |
| TCLK high-level width                                                                                 | <83> $t_{TKTKH}$  | 60                                     |      | 55                                     |      | 50                                     |      | ns   |
| TCLK low-level width                                                                                  | <84> $t_{TKTKL}$  | 60                                     |      | 55                                     |      | 50                                     |      | ns   |
| TCLK cycle                                                                                            | <85> $t_{CYTK}$   | 200                                    | DC   | 166                                    | DC   | 125                                    | DC   | ns   |
| Access interval <sup>Note 1</sup>                                                                     | <86> $t_{AI}$     | $2t_{CYK}-70$                          |      | $2t_{CYK}-60$                          |      | $2t_{CYK}-50$                          |      | ns   |
| $\overline{\text{REFRQ}}\uparrow$ delay time (vs. $\overline{\text{MRD}}\uparrow$ ) <sup>Note 2</sup> | <87> $t_{DRQHRH}$ | $t_{KKL}-50$                           |      | $t_{KKL}-40$                           |      | $t_{KKL}-30$                           |      | ns   |
| $\overline{\text{RESET}}$ pulse width <sup>Note 3</sup>                                               | <88> $t_{WRESL}$  | $4t_{CYK}$                             |      | $4t_{CYK}$                             |      | $4t_{CYK}$                             |      | ns   |

**Notes** 1. Specification to guarantee read/write recovery time for I/O device.2. Specification to guarantee that  $\overline{\text{REFRQ}}\uparrow$  is always later than  $\overline{\text{MRD}}\uparrow$ .

Only guaranteed when the EREF bit of the SCTL register is 0.

3. When using internal clock generator by connecting a resonator to the X1 and X2 pins, the oscillation stabilization time must be added at power-ON. Because the oscillation stabilization time varies depending on the characteristics of the resonator and oscillator used, evaluate the oscillation stabilization time with the resonator and oscillator actually used.

(2)  $\mu$ PD70208H, 70216H-20 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 3$  V  $\pm 10\%$ ) (1/3)Output Pin Load Capacitance:  $C_L = 100$  pF

| Parameter                                                                       | Symbol           | $\mu$ PD70208H-20<br>$\mu$ PD70216H-20 |      | Unit |
|---------------------------------------------------------------------------------|------------------|----------------------------------------|------|------|
|                                                                                 |                  | MIN.                                   | MAX. |      |
| External clock input cycle                                                      | <1> $t_{CYX}$    | 50                                     | DC   | ns   |
| External clock input high-level width ( $V_{KH}=0.8 V_{DD}$ )                   | <2> $t_{XXH}$    | 19                                     |      | ns   |
| External clock input low-level width ( $V_{KL}=0.2 V_{DD}$ )                    | <3> $t_{XXL}$    | 19                                     |      | ns   |
| External clock input rise time ( $0.2 V_{DD} \rightarrow 0.8 V_{DD}$ )          | <4> $t_{XR}$     |                                        | 5    | ns   |
| External clock input fall time ( $0.8 V_{DD} \rightarrow 0.2 V_{DD}$ )          | <5> $t_{XF}$     |                                        | 5    | ns   |
| Clock output cycle                                                              | <6> $t_{CYK}$    | 100                                    | DC   | ns   |
| Clock output high-level width ( $V_{OH}=0.7 V_{DD}$ )                           | <7> $t_{KKH}$    | $0.5t_{CYK}-7$                         |      | ns   |
| Clock output low-level width ( $V_{OL}=0.2 V_{DD}$ )                            | <8> $t_{KKL}$    | $0.5t_{CYK}-7$                         |      | ns   |
| Clock output rise time ( $0.2 V_{DD} \rightarrow 0.7 V_{DD}$ )                  | <9> $t_{KR}$     |                                        | 7    | ns   |
| Clock output fall time ( $0.7 V_{DD} \rightarrow 0.2 V_{DD}$ )                  | <10> $t_{KF}$    |                                        | 7    | ns   |
| CLKOUT delay time (vs. external clock)                                          | <11> $t_{DXK}$   |                                        | 45   | ns   |
| Input rise time (except external clock) ( $0.2 V_{DD} \rightarrow 0.7 V_{DD}$ ) | <12> $t_{IR}$    |                                        | 15   | ns   |
| Input fall time (except external clock) ( $0.7 V_{DD} \rightarrow 0.2 V_{DD}$ ) | <13> $t_{IF}$    |                                        | 10   | ns   |
| Output rise time (except CLKOUT) ( $0.2 V_{DD} \rightarrow 0.7 V_{DD}$ )        | <14> $t_{OR}$    |                                        | 15   | ns   |
| Output fall time (except CLKOUT) ( $0.7 V_{DD} \rightarrow 0.2 V_{DD}$ )        | <15> $t_{OF}$    |                                        | 10   | ns   |
| $\overline{\text{RESET}}$ setup time (vs. CLKOUT $\downarrow$ ) <b>Note 1</b>   | <16> $t_{SRESK}$ | 25                                     |      | ns   |
| $\overline{\text{RESET}}$ hold time (vs. CLKOUT $\downarrow$ ) <b>Note 1</b>    | <17> $t_{HKRES}$ | 25                                     |      | ns   |
| RESOUT output delay time (vs. CLKOUT $\downarrow$ )                             | <18> $t_{DKRES}$ | 5                                      | 50   | ns   |
| READY inactive setup time (vs. CLKOUT $\uparrow$ )                              | <19> $t_{SRYLK}$ | 15                                     |      | ns   |
| READY inactive hold time (vs. CLKOUT $\uparrow$ )                               | <20> $t_{HKRYL}$ | 20                                     |      | ns   |
| READY active setup time (vs. CLKOUT $\uparrow$ )                                | <21> $t_{SRYHK}$ | 15                                     |      | ns   |
| READY active hold time (vs. CLKOUT $\uparrow$ )                                 | <22> $t_{HKRYH}$ | 20                                     |      | ns   |
| NMI setup time (vs. CLKOUT $\uparrow$ )                                         | <23> $t_{SNMIK}$ | 15                                     |      | ns   |
| POLL setup time (vs. CLKOUT $\uparrow$ )                                        | <24> $t_{SPOLK}$ | 20                                     |      | ns   |
| Data setup time (vs. CLKOUT $\downarrow$ )                                      | <25> $t_{SDK}$   | 15                                     |      | ns   |
| Data hold time (vs. CLKOUT $\downarrow$ )                                       | <26> $t_{HKD}$   | 5                                      |      | ns   |
| CLKOUT $\rightarrow$ address delay time <b>Note 2</b>                           | <27> $t_{DKA}$   | 5                                      | 50   | ns   |
| ★ CLKOUT $\rightarrow$ address hold time                                        | <28> $t_{HKA}$   | 5                                      |      | ns   |
| CLKOUT $\downarrow \rightarrow$ PS delay time                                   | <29> $t_{DKP}$   | 5                                      | 50   | ns   |
| CLKOUT $\downarrow \rightarrow$ PS float delay time                             | <30> $t_{FKP}$   | 5                                      | 50   | ns   |
| Address setup time (vs. ASTB $\downarrow$ )                                     | <31> $t_{SAST}$  | $t_{KKL}-20$                           |      | ns   |
| CLKOUT $\downarrow \rightarrow$ address float delay time <b>Note 3</b>          | <32> $t_{FKA}$   | $t_{HKA}$                              | 50   | ns   |
| CLKOUT $\downarrow \rightarrow$ ASTB $\uparrow$ delay time                      | <33> $t_{DKSTH}$ |                                        | 40   | ns   |
| CLKOUT $\uparrow \rightarrow$ ASTB $\downarrow$ delay time                      | <34> $t_{DKSTL}$ |                                        | 45   | ns   |
| ASTB high-level width                                                           | <35> $t_{STST}$  | $t_{KKL}-10$                           |      | ns   |

- Notes**
1. When reset with the minimum pulse width or when guaranteeing the RESOUT output timing.
  2. Specifications also corresponding to the QS0, QS1, and  $\overline{\text{BUSLOCK}}$  signals, and A16/PS0-A19/PS3,  $\overline{\text{UBE}}$ ,  $\overline{\text{BUFEN}}$ ,  $\overline{\text{BUFR/W}}$ ,  $\overline{\text{MRD}}$ ,  $\overline{\text{IORD}}$ ,  $\overline{\text{MWR}}$ ,  $\overline{\text{IOWR}}$ , and BS0-BS2 signals at HLDRQ/HLDAK timing.
  3. Specifications also corresponding to the A16/PS0-A19/PS3,  $\overline{\text{UBE}}$ ,  $\overline{\text{BUFEN}}$ ,  $\overline{\text{BUFR/W}}$ ,  $\overline{\text{MRD}}$ ,  $\overline{\text{IORD}}$ ,  $\overline{\text{MWR}}$ ,  $\overline{\text{IOWR}}$ , and BS0-BS2 signals at HLDRQ/HLDAK timing.

(2)  $\mu$ PD70208H, 70216H-20 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 3$  V  $\pm 10\%$ ) (2/3)Output Pin Load Capacitance:  $C_L = 100$  pF

| Parameter                                                                                                      | Symbol             | $\mu$ PD70208H-20<br>$\mu$ PD70216H-20 |               | Unit |
|----------------------------------------------------------------------------------------------------------------|--------------------|----------------------------------------|---------------|------|
|                                                                                                                |                    | MIN.                                   | MAX.          |      |
| ASTB $\downarrow \rightarrow$ address hold time                                                                | <36> $t_{HSTA}$    | $t_{KKH}-20$                           |               | ns   |
| CLKOUT $\rightarrow$ control 1 <sup>Note 1</sup> delay time                                                    | <37> $t_{DKCT1}$   | 5                                      | 60            | ns   |
| CLKOUT $\rightarrow$ control 2 <sup>Note 2</sup> delay time                                                    | <38> $t_{DKCT2}$   | 5                                      | 55            | ns   |
| Address float $\rightarrow \overline{RD} \downarrow$ delay time                                                | <39> $t_{DAFRL}$   | 0                                      |               | ns   |
| CLKOUT $\downarrow \rightarrow \overline{RD} \downarrow$ delay time                                            | <40> $t_{DKRL}$    | 5                                      | 65            | ns   |
| CLKOUT $\downarrow \rightarrow \overline{RD} \uparrow$ delay time                                              | <41> $t_{DKRH}$    | 5                                      | 60            | ns   |
| $\overline{RD} \uparrow \rightarrow$ address delay time                                                        | <42> $t_{DRHA}$    | $t_{CYK}-40$                           |               | ns   |
| $\overline{RD}$ low-level width                                                                                | <43> $t_{RR}$      | $2t_{CYK}-40$                          |               | ns   |
| $\overline{BUFEN} \uparrow \rightarrow \overline{BUFR}/W$ delay time (read cycle)                              | <44> $t_{DBECT}$   | $t_{KKL}-20$                           |               | ns   |
| CLKOUT $\downarrow \rightarrow$ data output delay time                                                         | <45> $t_{DKD}$     | 5                                      | 55            | ns   |
| CLKOUT $\downarrow \rightarrow$ data float delay time                                                          | <46> $t_{FKD}$     | 5                                      | 55            | ns   |
| $\overline{WR}$ low-level width                                                                                | <47> $t_{WW}$      | $2t_{CYK}-40$                          |               | ns   |
| $\overline{WR} \uparrow \rightarrow \overline{BUFEN} \uparrow$ or $\overline{BUFR}/W \downarrow$ (write cycle) | <48> $t_{DWCT}$    | $t_{KKL}-20$                           |               | ns   |
| CLKOUT $\uparrow \rightarrow BS \downarrow$ delay time                                                         | <49> $t_{DKBL}$    | 5                                      | 55            | ns   |
| CLKOUT $\downarrow \rightarrow BS \uparrow$ delay time                                                         | <50> $t_{DKBH}$    | 5                                      | 55            | ns   |
| HLD $\overline{RQ}$ setup time (vs. CLKOUT $\downarrow$ )                                                      | <51> $t_{SHQK}$    | 15                                     |               | ns   |
| CLKOUT $\downarrow \rightarrow$ HLD $\overline{AK}$ delay time                                                 | <52> $t_{DKHA}$    | 5                                      | 60            | ns   |
| CLKOUT $\uparrow \rightarrow \overline{DMAAK}$ delay time                                                      | <53> $t_{DKHDA}$   | 5                                      | 55            | ns   |
| CLKOUT $\downarrow \rightarrow \overline{DMAAK}$ delay time (cascade mode)                                     | <54> $t_{DKLDA}$   | 5                                      | 80            | ns   |
| $\overline{WR}$ low-level width (DMA cycle)                                                                    | DMA extended write | <55> $t_{WW1}$                         | $2t_{CYK}-40$ | ns   |
|                                                                                                                | DMA normal write   | <56> $t_{WW2}$                         | $t_{CYK}-40$  | ns   |
| $\overline{RD} \downarrow, \overline{WR} \downarrow$ delay time (vs. $\overline{DMAAK} \downarrow$ )           | <57> $t_{DDARW}$   | $t_{KKH}-30$                           |               | ns   |
| $\overline{DMAAK} \uparrow$ delay time (vs. $\overline{RD} \uparrow$ )                                         | <58> $t_{DRHDAH}$  | $t_{KKL}-30$                           |               | ns   |
| $\overline{RD} \uparrow$ delay time (vs. $\overline{WR} \uparrow$ )                                            | <59> $t_{DWRH}$    | 3                                      |               | ns   |
| $\overline{TC}$ output delay time (vs. CLKOUT $\uparrow$ )                                                     | <60> $t_{DKTCL}$   |                                        | 55            | ns   |
| $\overline{TC}$ OFF delay time (vs. CLKOUT $\uparrow$ )                                                        | <61> $t_{DKTCF}$   |                                        | 55            | ns   |
| $\overline{TC}$ low-level width                                                                                | <62> $t_{TCTCL}$   | $t_{CYK}-15$                           |               | ns   |
| $\overline{TC}$ pull-up delay time (vs. CLKOUT $\uparrow$ )                                                    | <63> $t_{DKTCH}$   |                                        | <b>Note 3</b> | ns   |
| $\overline{END}$ setup time (vs. CLKOUT $\uparrow$ )                                                           | <64> $t_{SEDK}$    | 30                                     |               | ns   |
| $\overline{END}$ low-level width                                                                               | <65> $t_{EEDL}$    | 80                                     |               | ns   |
| DMA $\overline{RQ}$ setup time (vs. CLKOUT $\uparrow$ )                                                        | <66> $t_{SDQK}$    | 30                                     |               | ns   |
| INTP $\overline{n}$ low-level width                                                                            | <67> $t_{PIPL}$    | 80                                     |               | ns   |
| RxD setup time (vs. SCU internal clock $\downarrow$ )                                                          | <68> $t_{SRX}$     | 500                                    |               | ns   |
| RxD hold time (vs. SCU internal clock $\downarrow$ )                                                           | <69> $t_{HRX}$     | 500                                    |               | ns   |
| CLKOUT $\downarrow \rightarrow \overline{SRDY}$ delay time                                                     | <70> $t_{DKSR}$    |                                        | 100           | ns   |

- Notes**
1.  $\overline{MWR}$  and  $\overline{IOWR}$  signals in DMA cycle
  2.  $\overline{MWR}$  and  $\overline{IOWR}$  signals in CPU cycles and  $\overline{BUFEN}$ ,  $\overline{BUFR}/W$ ,  $\overline{INTAK}$  and  $\overline{REFRQ}$  signals.
  3.  $t_{KKH} + 2t_{CYK} - 10$  (reference value when a 1.1-k $\Omega$  pull-up resistor is connected)

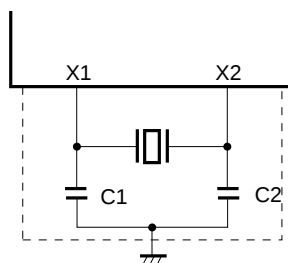
(2)  $\mu$ PD70208H, 70216H-20 ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 3$  V  $\pm 10\%$ ) (3/3)Output Pin Load Capacitance:  $C_L = 100$  pF

| Parameter                                                                                                   | Symbol            | $\mu$ PD70208H-20<br>$\mu$ PD70216H-20 |      | Unit |
|-------------------------------------------------------------------------------------------------------------|-------------------|----------------------------------------|------|------|
|                                                                                                             |                   | MIN.                                   | MAX. |      |
| TOUT1 $\downarrow \rightarrow$ TxD delay time                                                               | <71> $t_{DTX}$    |                                        | 200  | ns   |
| TCTL2 setup time (vs. CLKOUT $\downarrow$ )                                                                 | <72> $t_{SGK}$    | 40                                     |      | ns   |
| TCTL2 setup time (vs. TCLK $\uparrow$ )                                                                     | <73> $t_{SGTK}$   | 40                                     |      | ns   |
| TCTL2 hold time (vs. CLKOUT $\downarrow$ )                                                                  | <74> $t_{HKG}$    | 80                                     |      | ns   |
| TCTL2 hold time (vs. TCLK $\uparrow$ )                                                                      | <75> $t_{HTKG}$   | 40                                     |      | ns   |
| TCTL2 high-level width                                                                                      | <76> $t_{GGH}$    | 40                                     |      | ns   |
| TCTL2 low-level width                                                                                       | <77> $t_{GGL}$    | 40                                     |      | ns   |
| TOUT output delay time (vs. CLKOUT $\downarrow$ )                                                           | <78> $t_{DKTO}$   |                                        | 150  | ns   |
| TOUT output delay time (vs. TCLK $\downarrow$ )                                                             | <79> $t_{DTKTO}$  |                                        | 100  | ns   |
| TOUT output delay time (vs. TCTL2 $\downarrow$ )                                                            | <80> $t_{DGO}$    |                                        | 90   | ns   |
| TCLK rise time                                                                                              | <81> $t_{TKR}$    |                                        | 25   | ns   |
| TCLK fall time                                                                                              | <82> $t_{TKF}$    |                                        | 25   | ns   |
| TCLK high-level width                                                                                       | <83> $t_{TKTKH}$  | 45                                     |      | ns   |
| TCLK low-level width                                                                                        | <84> $t_{TKTKL}$  | 45                                     |      | ns   |
| TCLK cycle                                                                                                  | <85> $t_{CYTK}$   | 100                                    | DC   | ns   |
| Access interval <sup>Note 1</sup>                                                                           | <86> $t_{AI}$     | $2t_{CYK}-40$                          |      | ns   |
| $\overline{\text{REFRQ}}$ $\uparrow$ delay time (vs. $\overline{\text{MRD}}$ $\uparrow$ ) <sup>Note 2</sup> | <87> $t_{DRQHRH}$ | $t_{KKL}-30$                           |      | ns   |
| RESET pulse width <sup>Note 3</sup>                                                                         | <88> $t_{WRESL}$  | $4t_{CYK}$                             |      | ns   |

- Notes**
1. This rating is to guarantee the read/write recovery time for the I/O device.
  2. This rating is to guarantee that  $\overline{\text{REFRQ}}$   $\uparrow$  is always behind  $\overline{\text{MRD}}$   $\uparrow$ , and is guaranteed only when the EREF bit of the STCL register is 0.
  3. When using internal clock generator by connecting a resonator to the X1 and X2 pins, the oscillation stabilization time must be added at power-ON. Because the oscillation stabilization time varies depending on the characteristics of the resonator and oscillator used, evaluate the oscillation stabilization time with the resonator and oscillator actually used.

**RECOMMENDED OSCILLATOR**

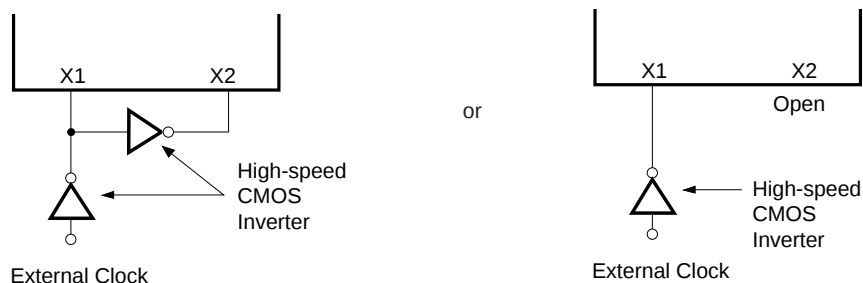
The clock input circuits (1) and (2) shown below are recommended.

**(1) Ceramic resonator connection ( $T_A = -40$  to  $+85$  °C,  $V_{DD} = 3$  V  $\pm 10\%$  <sup>Note</sup>)**

- Cautions**
1. The oscillator should be as close as possible to the X1 and X2 pins.
  2. No other signal lines should pass through the area enclosed in dashed line.
  3. V40HL, V50HL and resonator matching requires careful evaluation.
  4. The values of the oscillator constants C1 and C2 depend on the characteristics of the resonator used. Evaluate them with the resonator actually used.

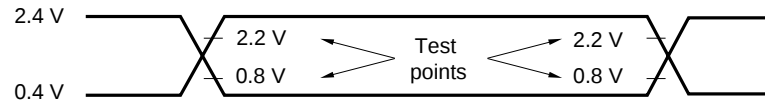
| Manufacturer          | Frequency ( $f_{xx}$ ) [MHz] | Product Name                   | Recommended Constant |         |
|-----------------------|------------------------------|--------------------------------|----------------------|---------|
|                       |                              |                                | C1 [pF]              | C2 [pF] |
| Murata Mfg. Co., Ltd. | 20                           | CSA20.00MXZ040 <sup>Note</sup> | 10                   | 10      |
|                       |                              | CSA16.00MXZ040                 | 15                   | 15      |
|                       | 16                           | CSA16.00MXW0C3                 | —                    | —       |
|                       |                              | CSA12.5MTZ                     | 30                   | 30      |
|                       | 12.5                         | CSA12.5MTW                     | —                    | —       |
|                       |                              | CSA10.0MTZ                     | 30                   | 30      |
| TDK Corp.             | 20                           | CST10.0MXW                     | —                    | —       |
|                       |                              | FCR20.0M2G                     | 10                   | 10      |
|                       | 16                           | FCR16.0M2G                     | 15                   | 15      |
|                       | 10                           | FCR10.0MC                      | —                    | —       |

**Note** Use the CAS20.00MXZ040 within the range of  $V_{DD} = 2.9$  to  $3.3$  V.

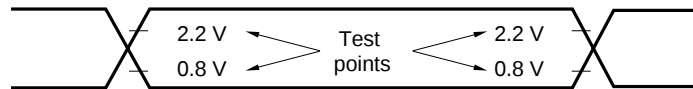
**(2) External clock input**

**Caution** The high-speed CMOS inverter should be as close as possible to the X1 and X2 pins.

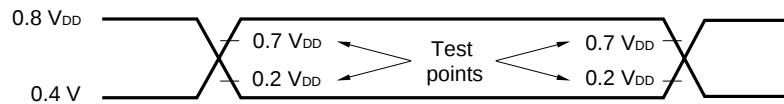
AC Test Input Waveform (Except X1 and X2) (at 5 V operation)



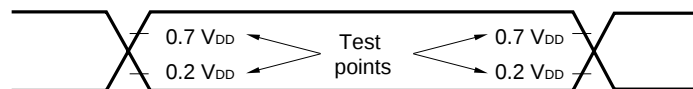
AC Test Output Test Points (at 5 V operation)



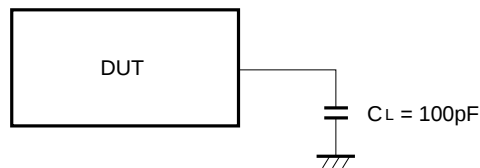
AC Test Input Waveform (Except X1 and X2) (at 3 V operation)



AC Test Output Waveform (at 3 V operation)

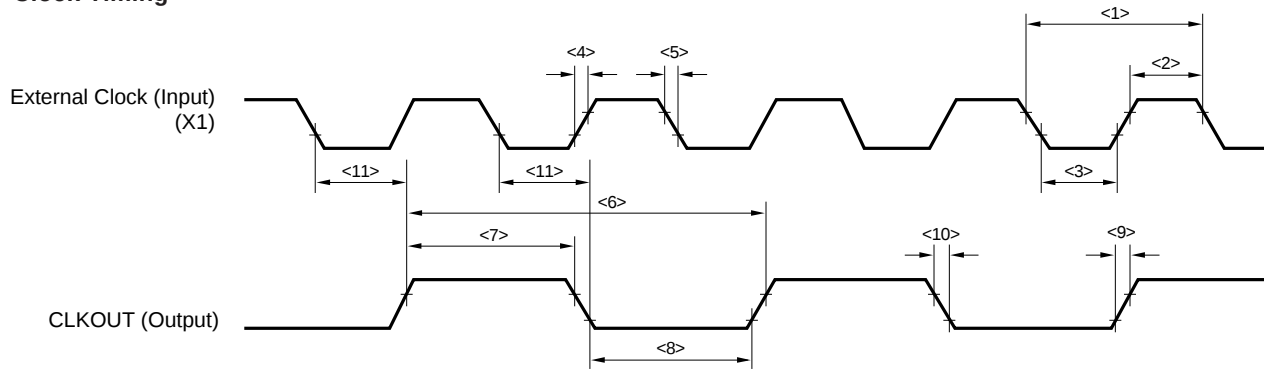


Load Conditions

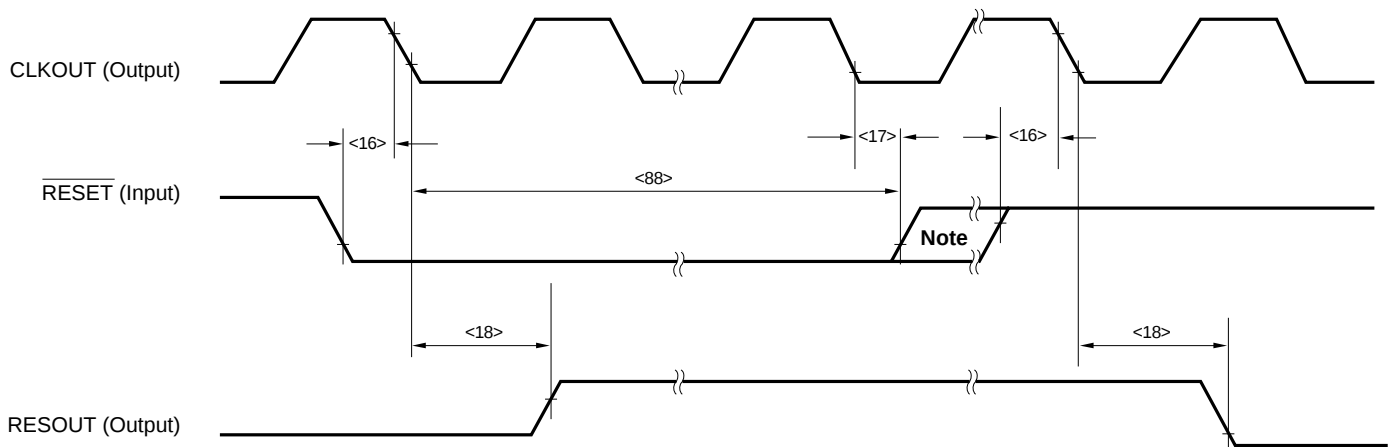


**Caution** If the load capacitance exceeds 100 pF due to the configuration of the circuit, the load capacitance of this device should be reduced to 100 pF or less by insertion of a buffer, etc.

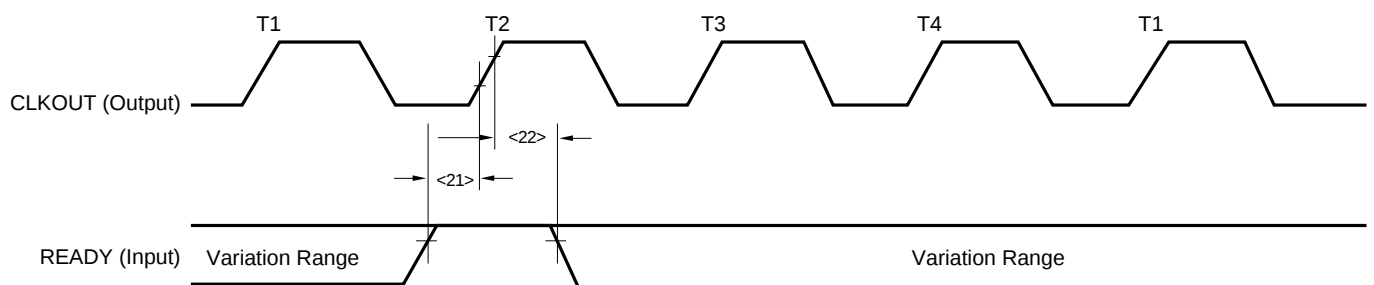
### Clock Timing



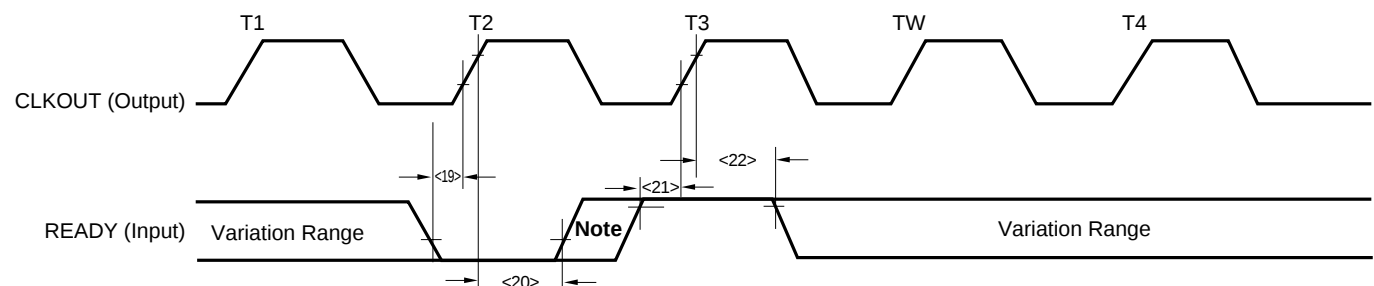
### Reset Timing



### Ready Timing (1)

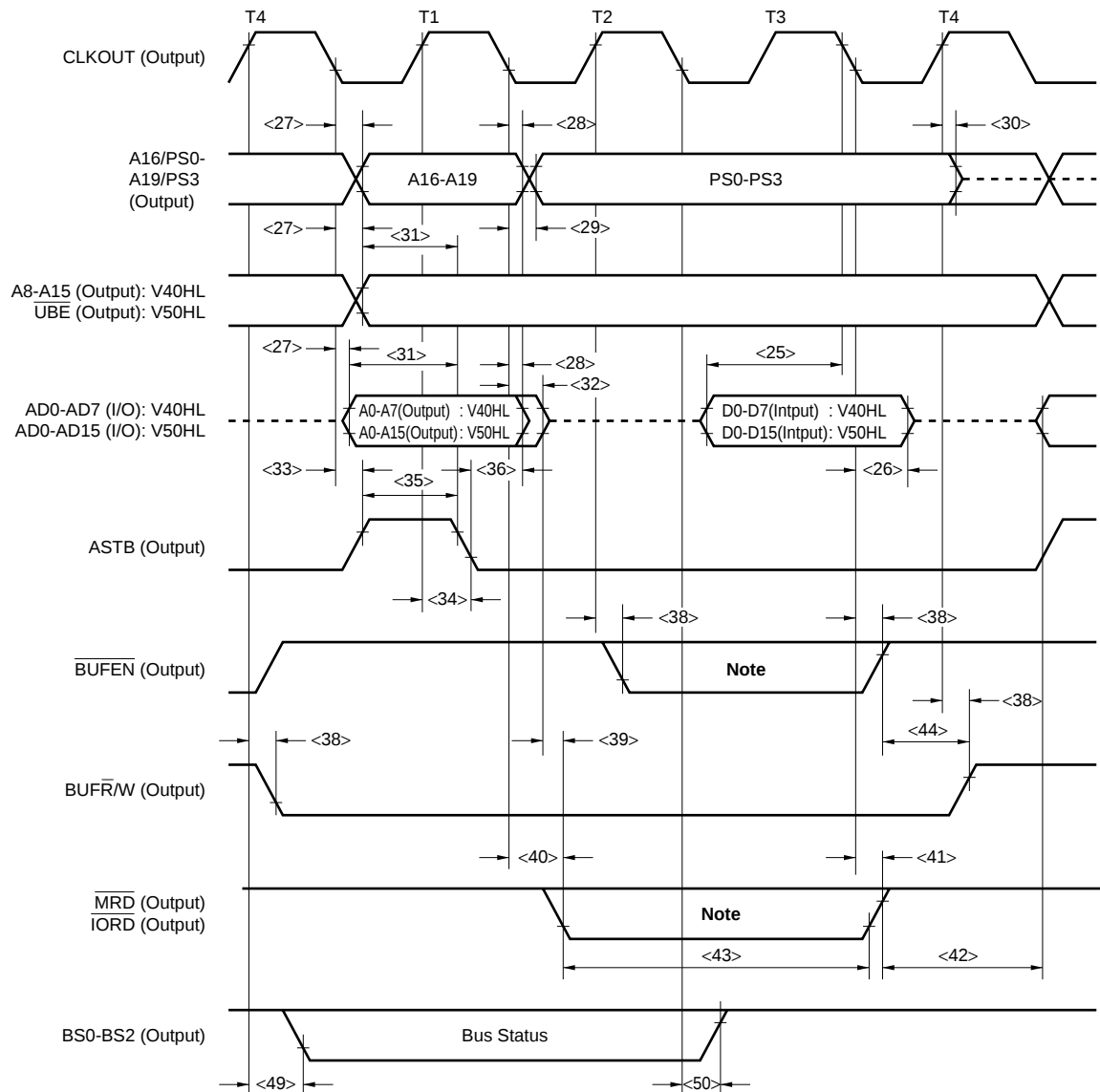


### Ready Timing (2)



**Note** Variation range

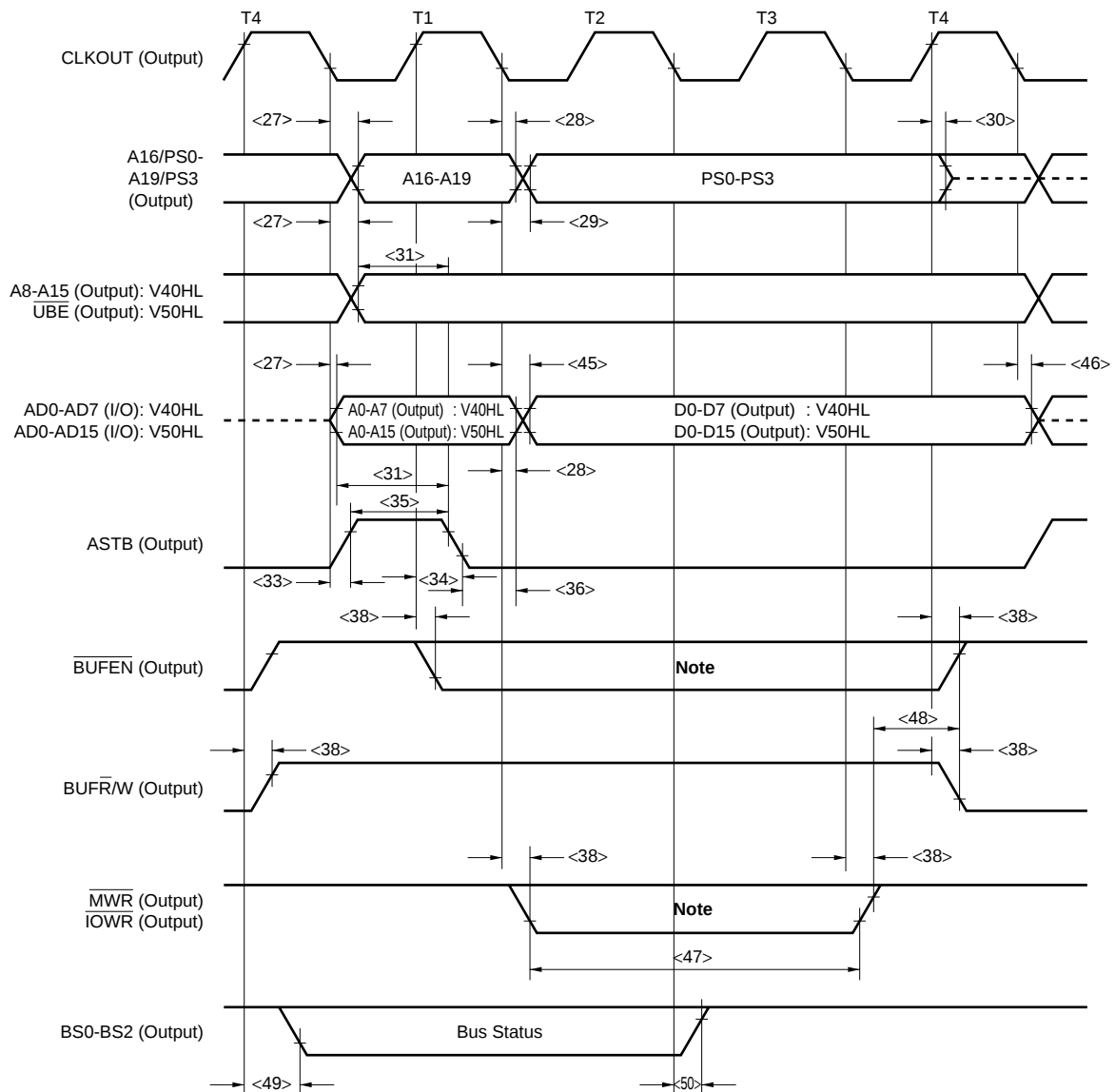
## Read Timing



**Note** High-level signal is output in case of internal access.

**Remark** A dashed line indicates high impedance.

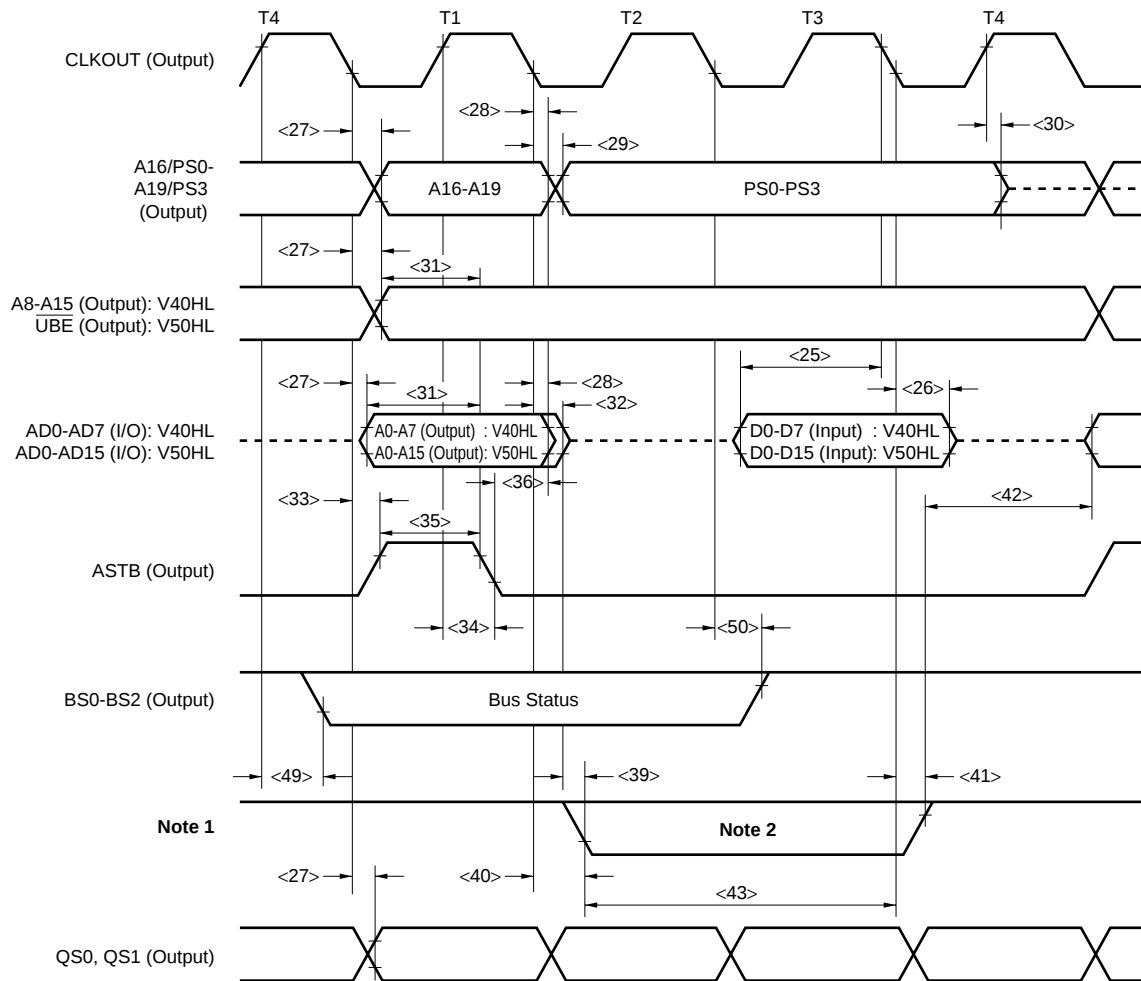
# Write Timing



**Note** High-level signal is output in case of internal access.

**Remark** A dashed line indicates high impedance.

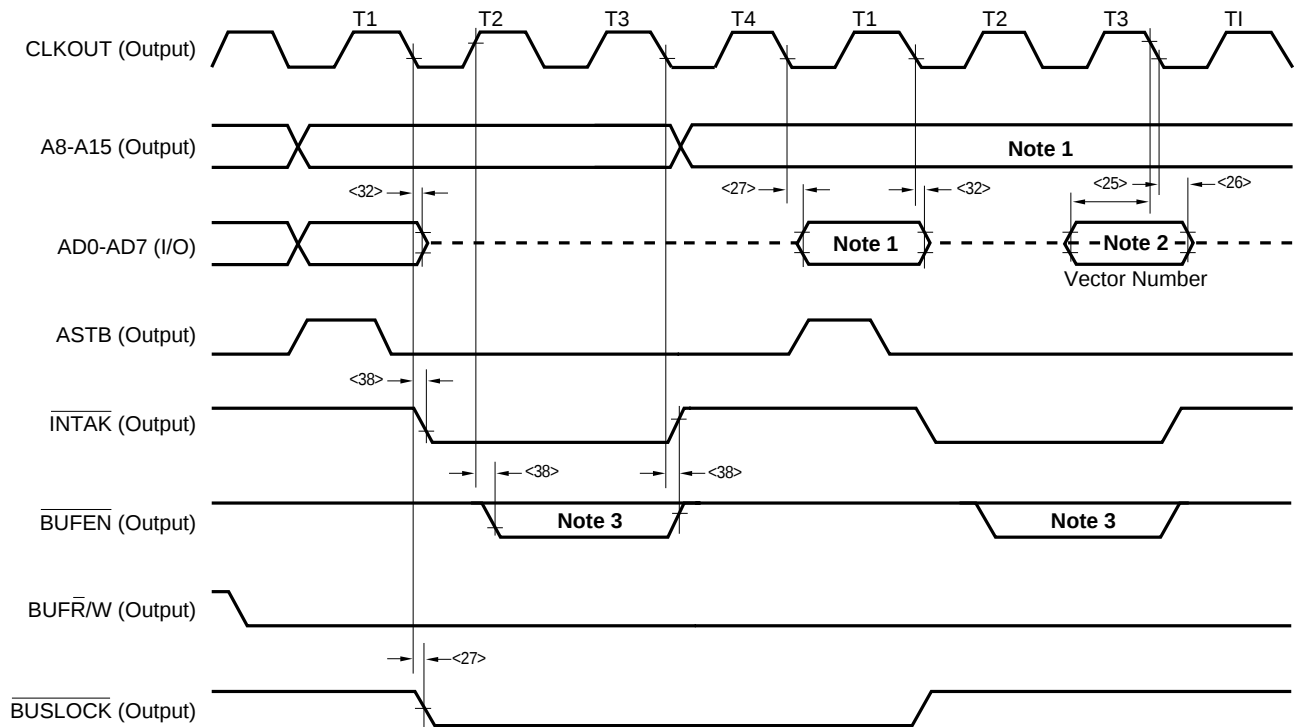
# Status Timing



- Notes** 1.  $\overline{\text{MRD}}$ ,  $\overline{\text{IORD}}$ ,  $\overline{\text{MWR}}$ ,  $\overline{\text{IOWR}}$  (all output)  
2. High-level signal is output in case of internal access.

**Remark** A dashed line indicates high impedance.

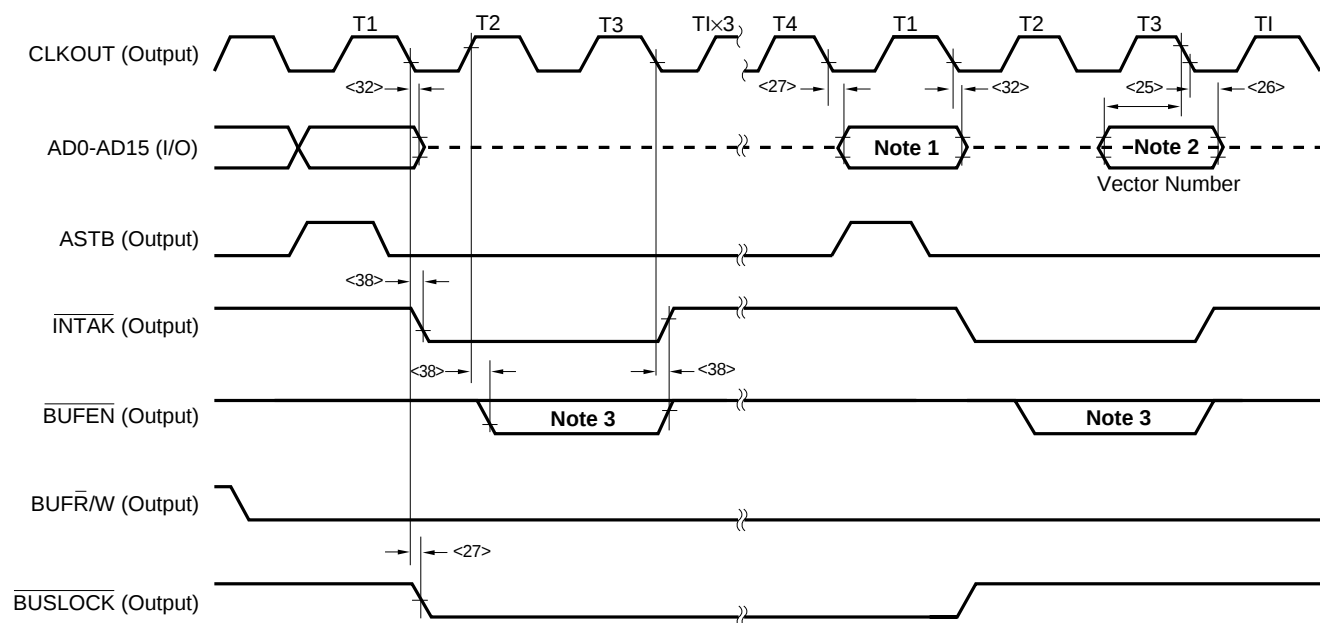
### Interrupt Acknowledge Timing (V40HL)



- Notes**
1. Slave address in case of interrupt from external μPD71059.  
Invalid data in case of interrupt from internal ICU.
  2. Data read as vector address in case of interrupt from external μPD71059.  
High impedance in case of interrupt from internal ICU.
  3. Low-level output in case of interrupt from external μPD71059.  
High-level output in case of interrupt from internal ICU.

**Remark** A dashed line indicates high impedance.

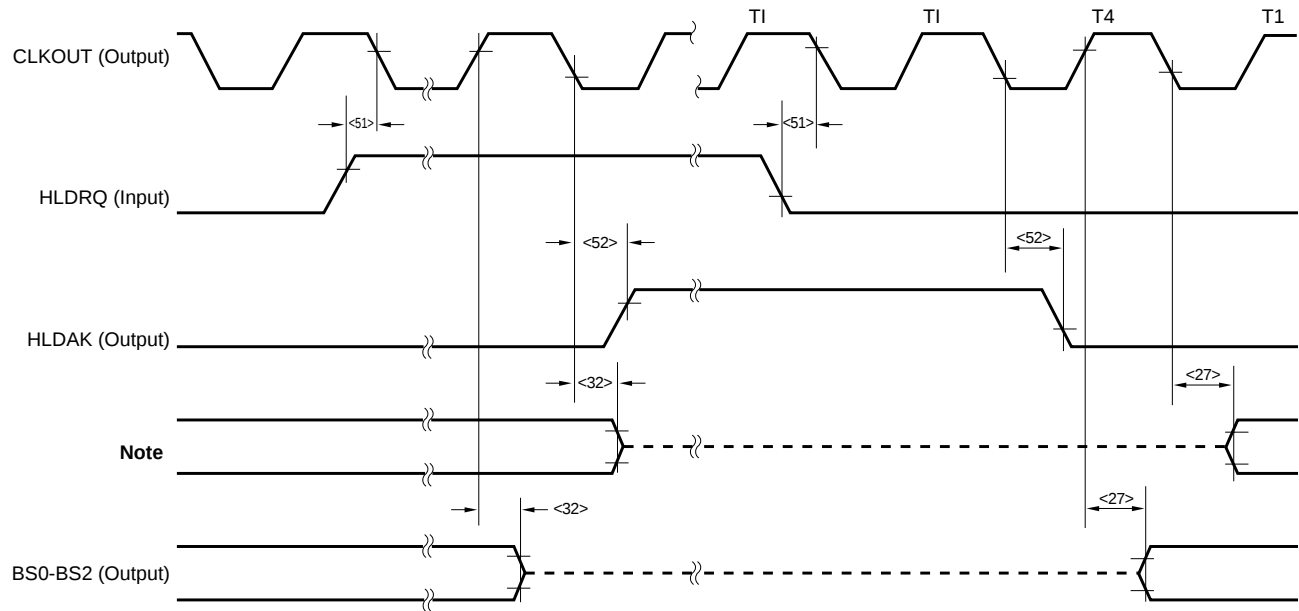
# Interrupt Acknowledge Timing (V50HL)



- Notes**
1. Slave address in case of interrupt from external μPD71059.  
Invalid data in case of interrupt from internal ICU.
  2. Data read as vector address in case of interrupt from external μPD71059.  
High impedance in case of interrupt from internal ICU.
  3. Low-level output in case of interrupt from external μPD71059.  
High-level output in case of interrupt from internal ICU.

**Remark** A dashed line indicates high impedance.

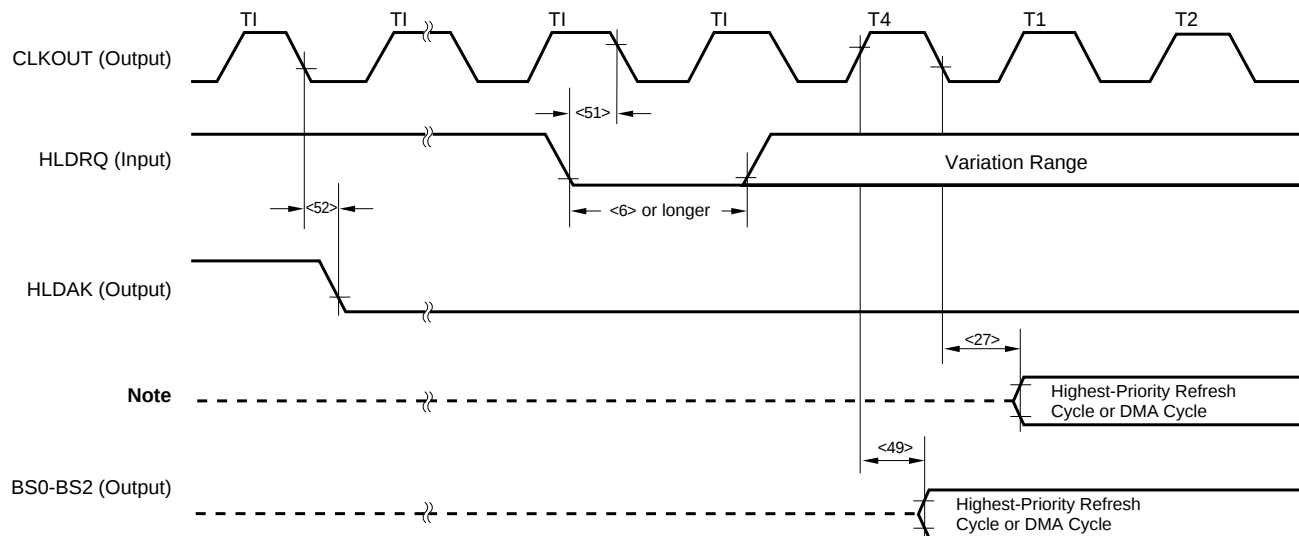
## HLDRQ/HLDAK Timing (1)



**Note** A16/PS0 to A19/PS3,  $\overline{UBE}$ ,  $\overline{BUFEN}$ ,  $\overline{BUFR/W}$ ,  $\overline{MRD}$ ,  $\overline{IORD}$ ,  $\overline{MWR}$ ,  $\overline{IOWR}$  (all output): V40HL, V50HL  
 A8-A15 (output): V40HL AD0-AD7 (input/output): V40HL AD0-AD15 (input/output) V50HL

**Remark** A dashed line indicates high impedance.

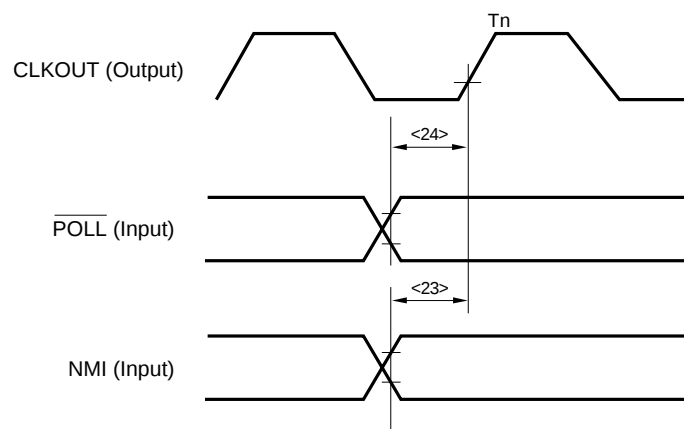
## HLDRQ/HLDAK Timing (2)



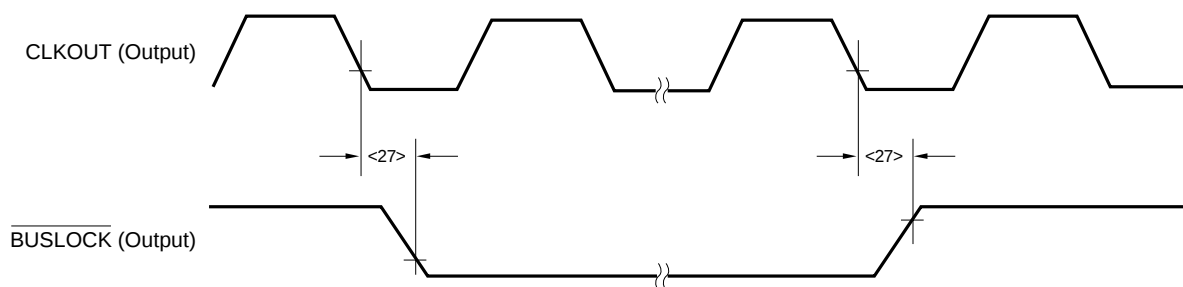
**Note** A16/PS0 to A19/PS3,  $\overline{UBE}$ ,  $\overline{BUFEN}$ ,  $\overline{BUFR/W}$ ,  $\overline{MRD}$ ,  $\overline{IORD}$ ,  $\overline{MWR}$ ,  $\overline{IOWR}$  (all output): V40HL, V50HL  
 A8-A15 (output): V40HL AD0-AD7 (input/output): V40HL AD0-AD15 (input/output) V50HL

**Remark** A dashed line indicates high impedance.

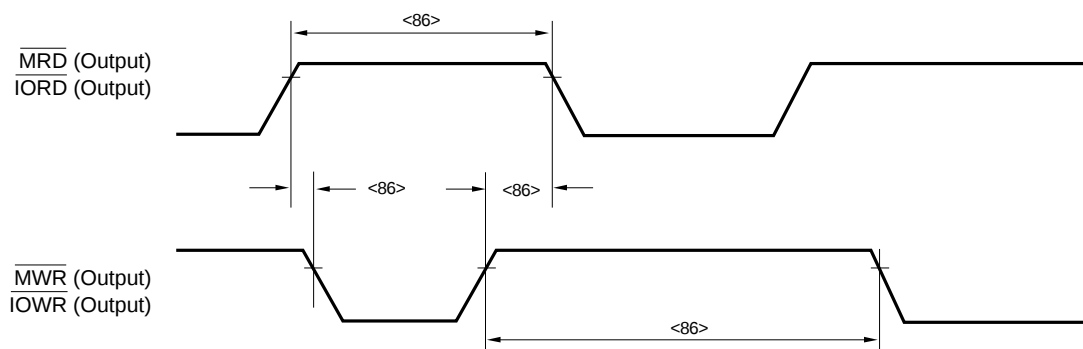
### $\overline{\text{POLL}}$ , NMI Input Timing



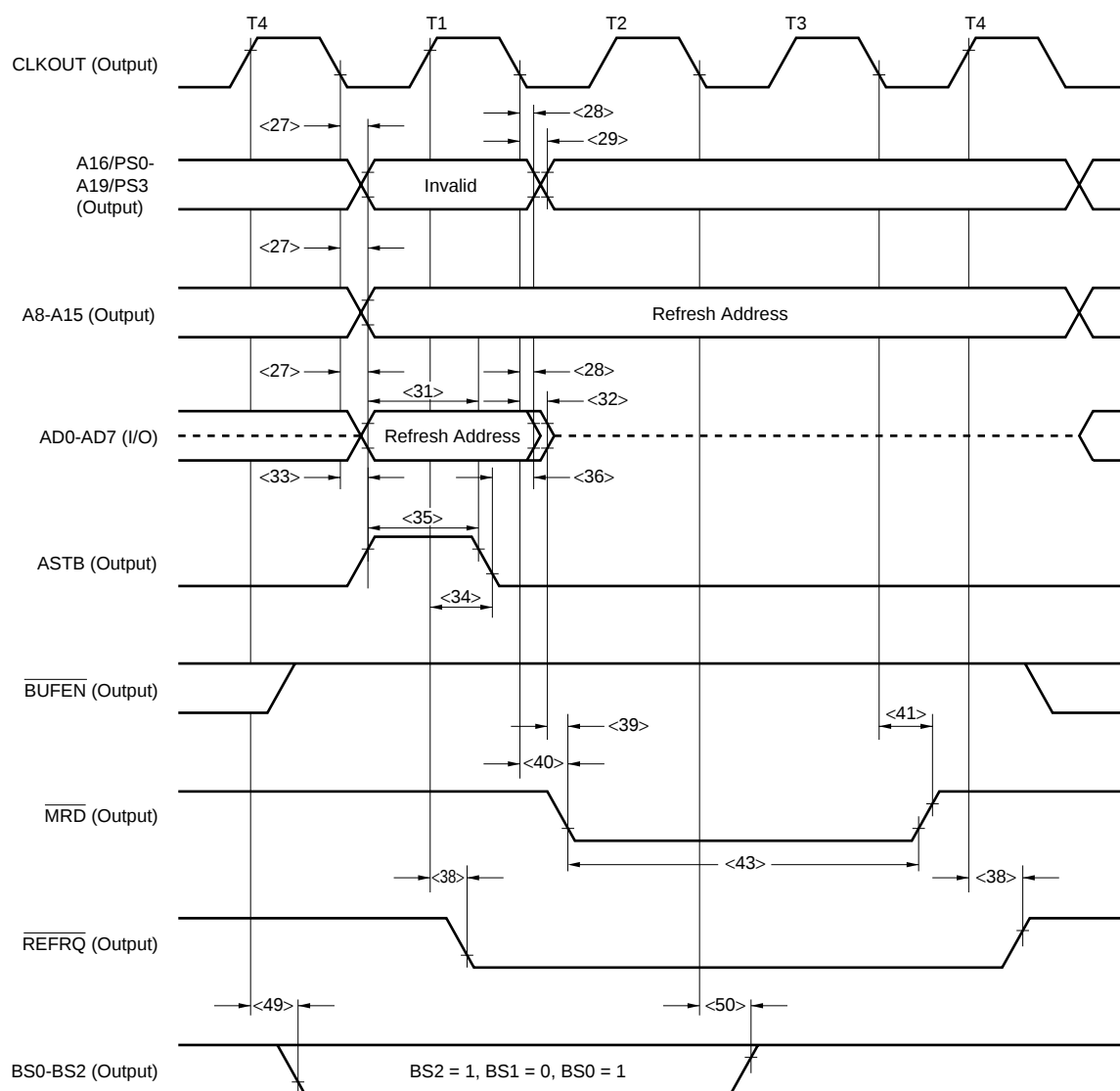
### $\overline{\text{BUSLOCK}}$ Output Timing



### Access Interval

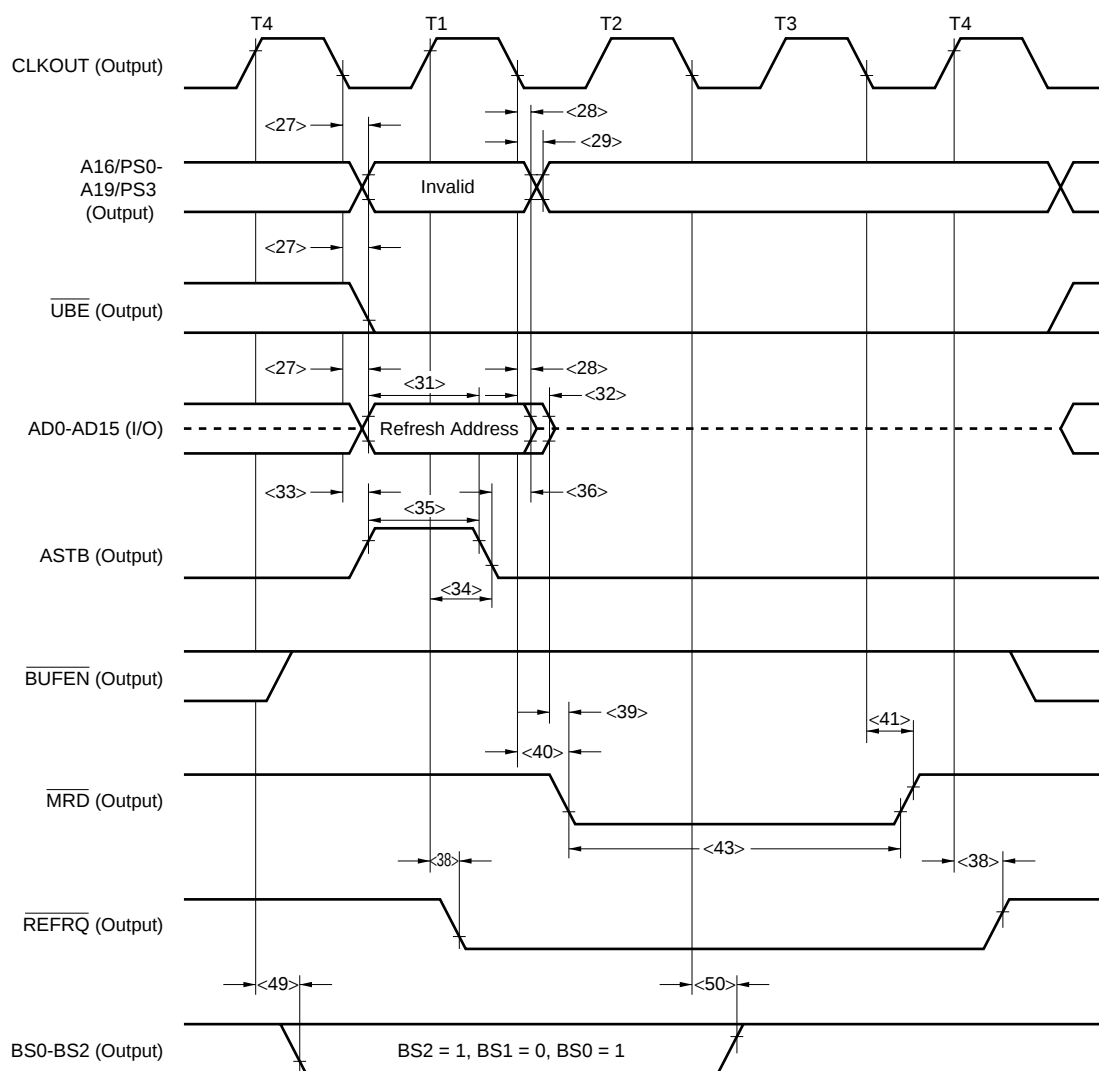


## Refresh Timing (V40HL)



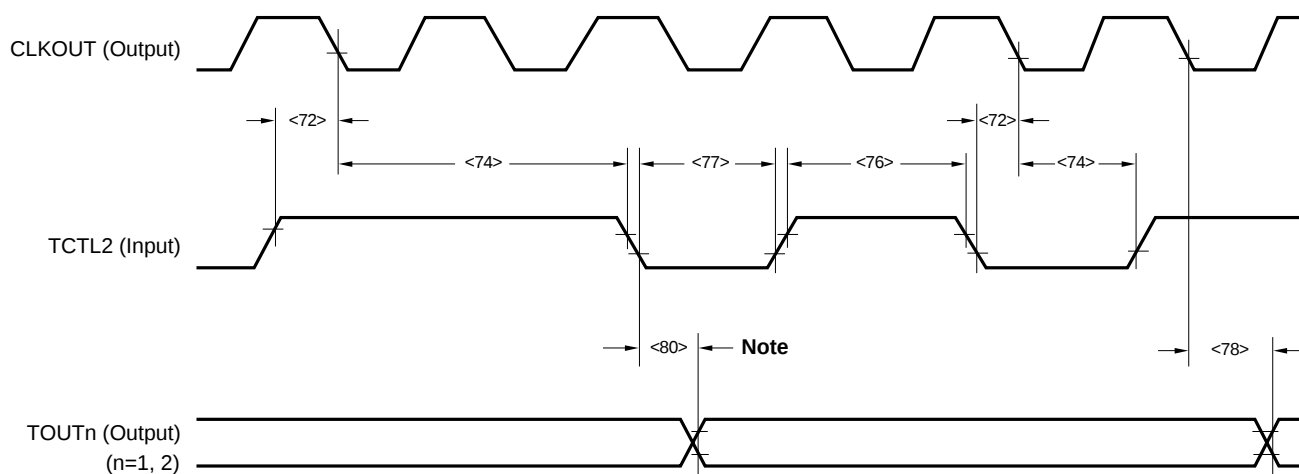
**Remark** A dashed line indicates high impedance.

## Refresh Timing (V50HL)

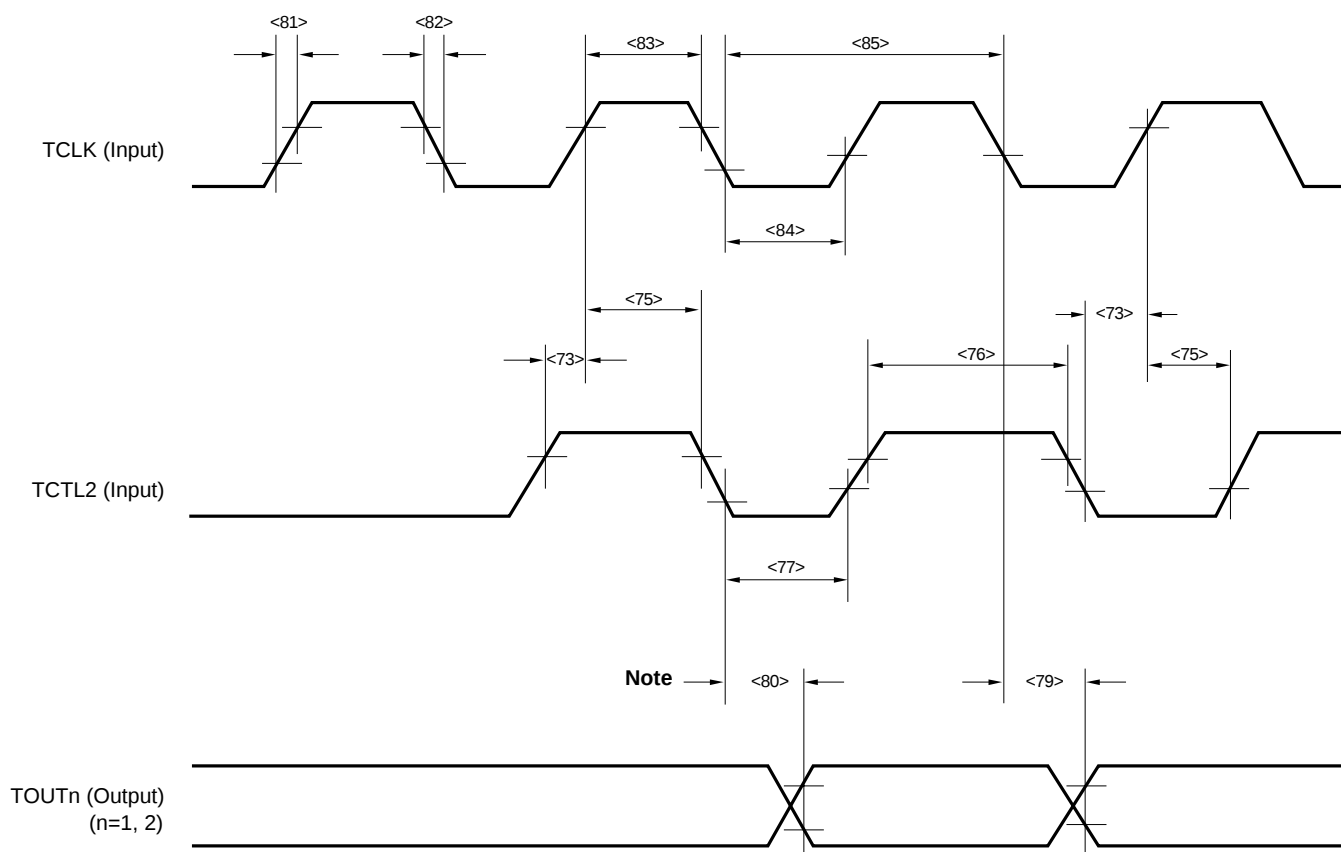


**Remark** A dashed line indicates high impedance.

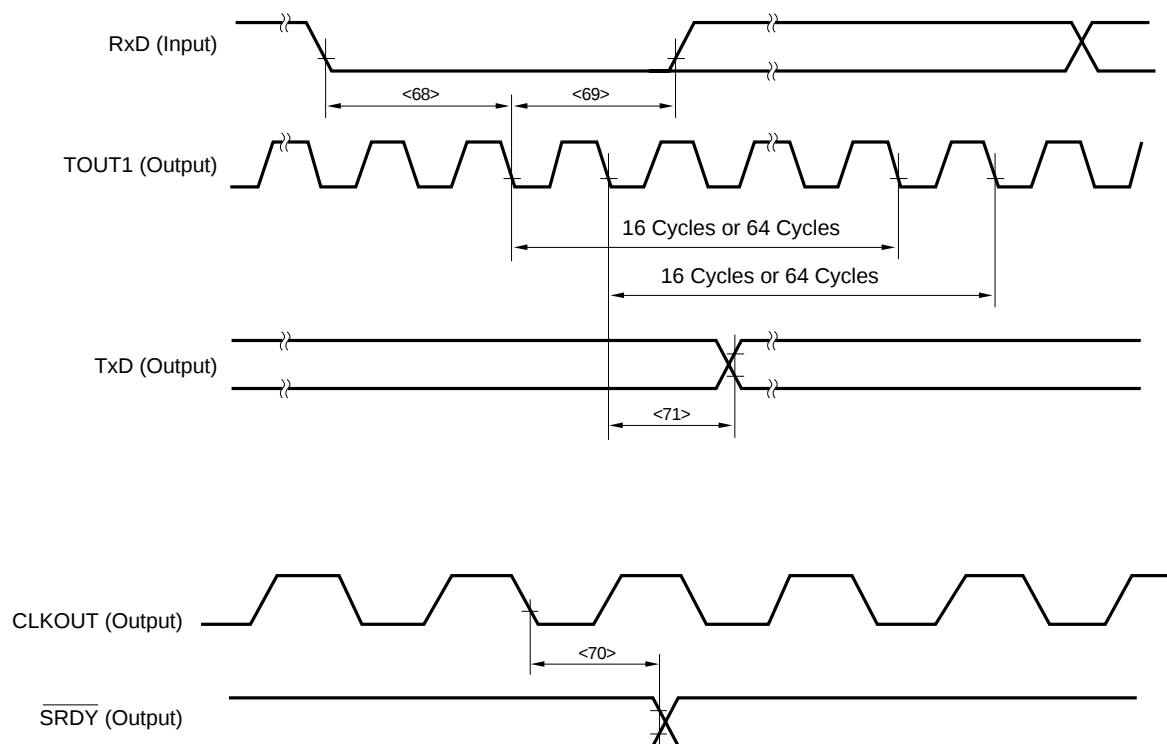
## TCU Timing (1)



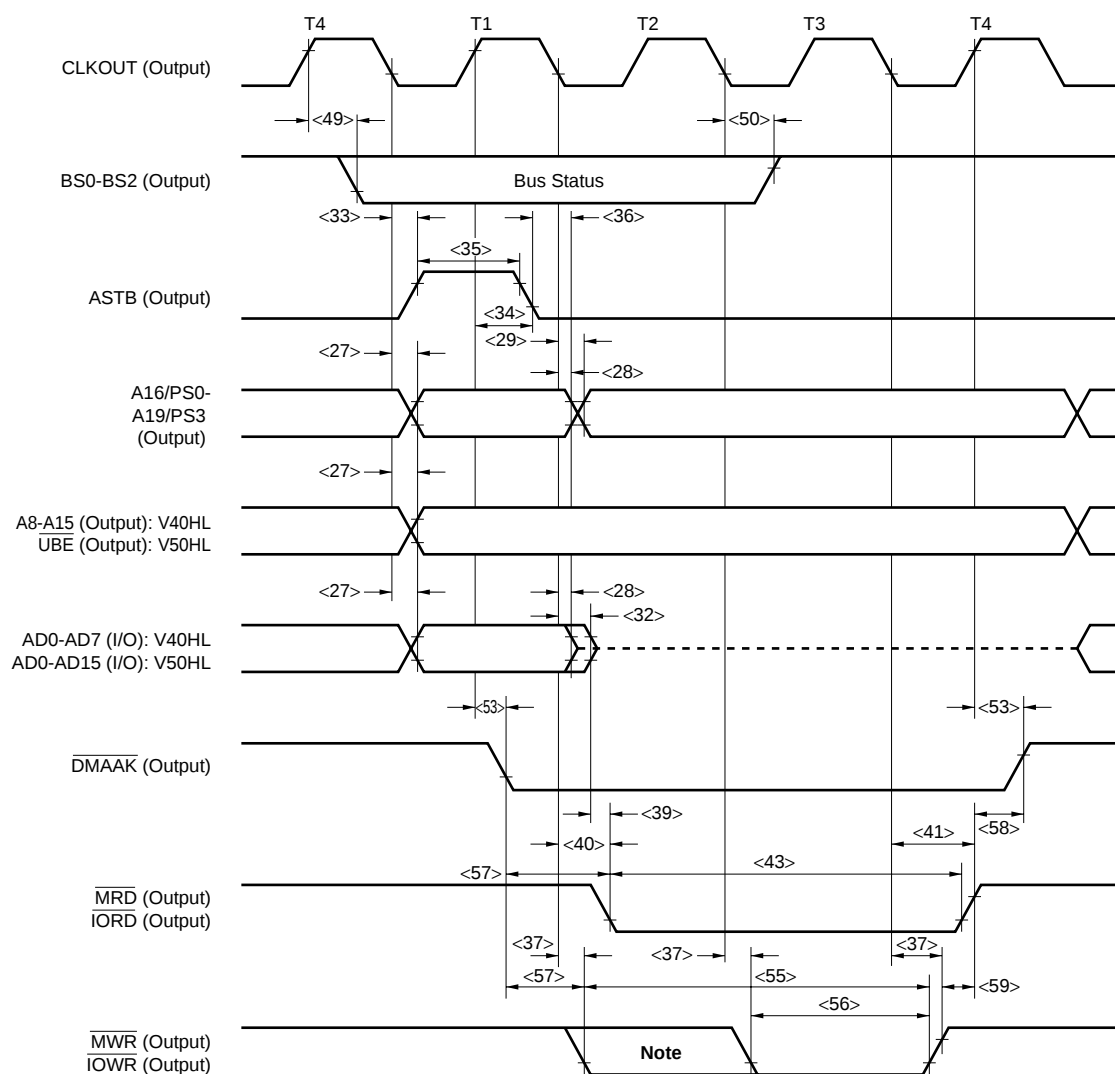
## TCU Timing (2)



# SCU Timing



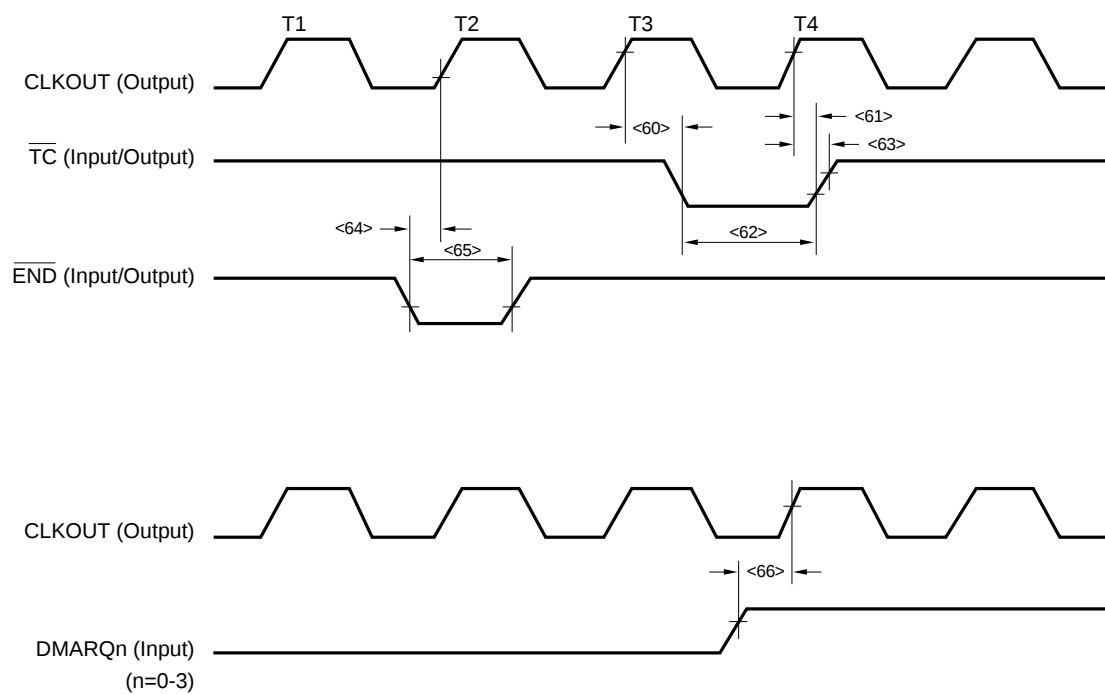
## DMAU Timing (1)



**Note** Low-level signal is output in extended write mode.

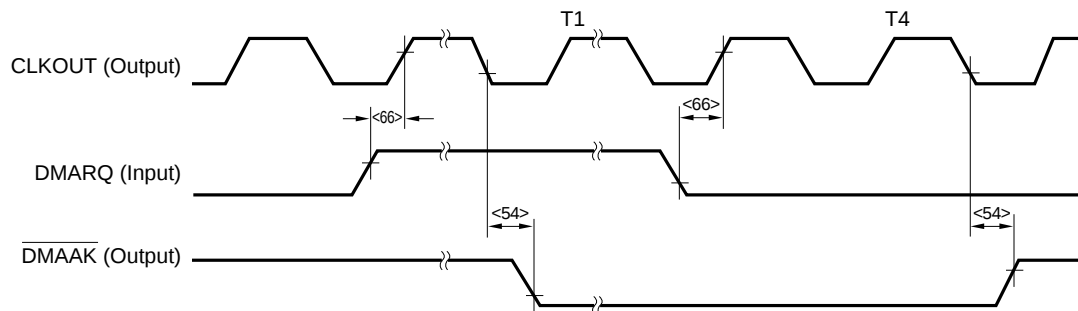
**Remark** A dashed line indicates high impedance.

DMAU Timing (2)

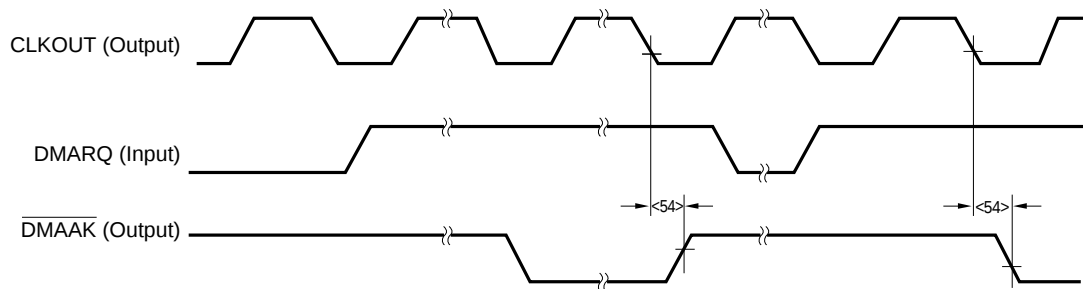


### DMAU Timing (3) (Cascade Mode)

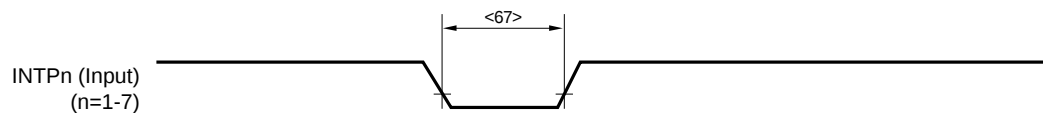
In Normal Operation:



When Refresh Cycle is Inserted:

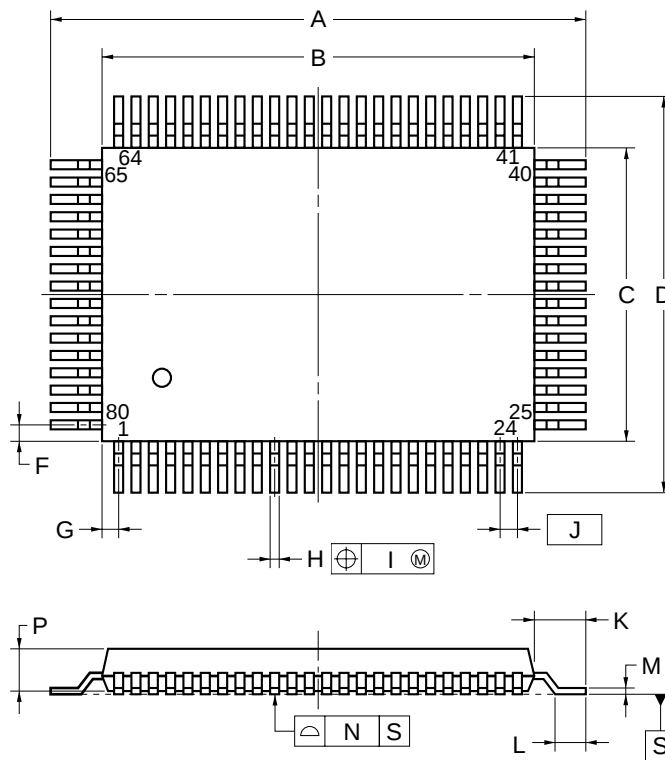


### ICU Timing

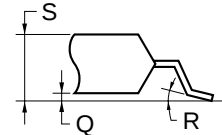


## 17. PACKAGE DRAWINGS

## 80 PIN PLASTIC QFP (14x20)



detail of lead end

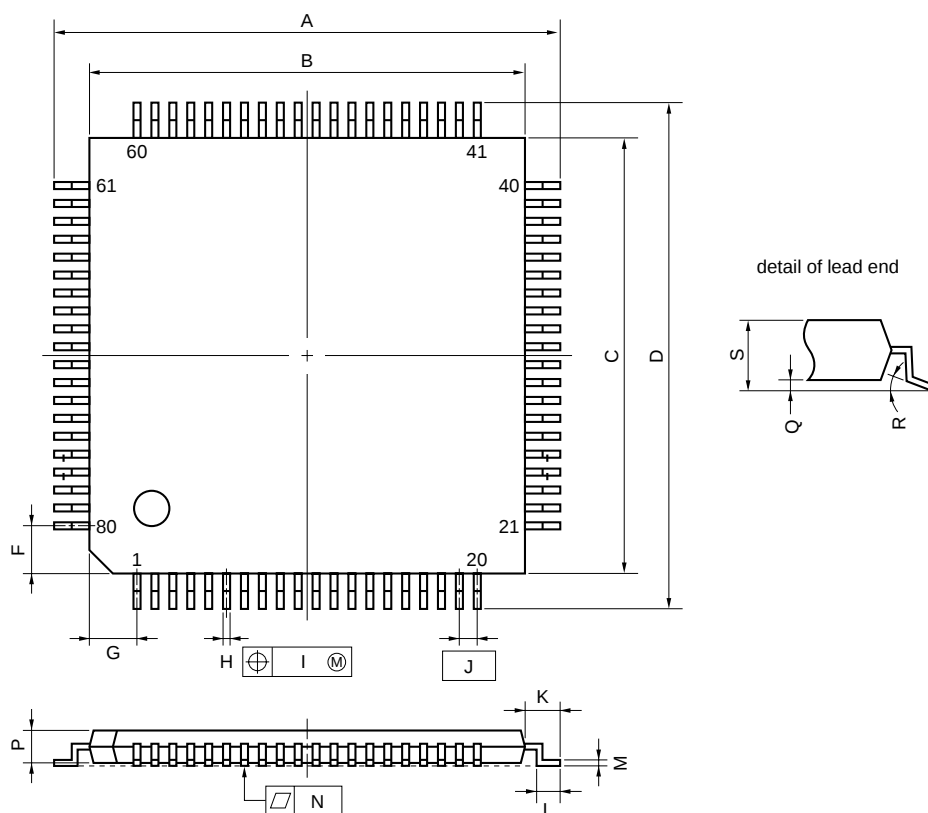
**NOTE**

1. Controlling dimension — millimeter.
2. Each lead centerline is located within 0.15 mm (0.006 inch) of its true position (T.P.) at maximum material condition.

| ITEM | MILLIMETERS                            | INCHES                                    |
|------|----------------------------------------|-------------------------------------------|
| A    | 23.6±0.4                               | 0.929±0.016                               |
| B    | 20.0±0.2                               | 0.795 <sup>+0.009</sup> <sub>-0.008</sub> |
| C    | 14.0±0.2                               | 0.551 <sup>+0.009</sup> <sub>-0.008</sub> |
| D    | 17.6±0.4                               | 0.693±0.016                               |
| F    | 1.0                                    | 0.039                                     |
| G    | 0.8                                    | 0.031                                     |
| H    | 0.37 <sup>+0.08</sup> <sub>-0.07</sub> | 0.015 <sup>+0.003</sup> <sub>-0.004</sub> |
| I    | 0.15                                   | 0.006                                     |
| J    | 0.8 (T.P.)                             | 0.031 (T.P.)                              |
| K    | 1.8±0.2                                | 0.071 <sup>+0.008</sup> <sub>-0.009</sub> |
| L    | 0.8±0.2                                | 0.031 <sup>+0.009</sup> <sub>-0.008</sub> |
| M    | 0.17 <sup>+0.08</sup> <sub>-0.07</sub> | 0.007 <sup>+0.003</sup> <sub>-0.004</sub> |
| N    | 0.10                                   | 0.004                                     |
| P    | 2.7±0.1                                | 0.106 <sup>+0.005</sup> <sub>-0.004</sub> |
| Q    | 0.1±0.1                                | 0.004±0.004                               |
| R    | 5°±5°                                  | 5°±5°                                     |
| S    | 3.0 MAX.                               | 0.119 MAX.                                |

P80GF-80-3B9-4

# 80 PIN PLASTIC TQFP (FINE PITCH) (□12)



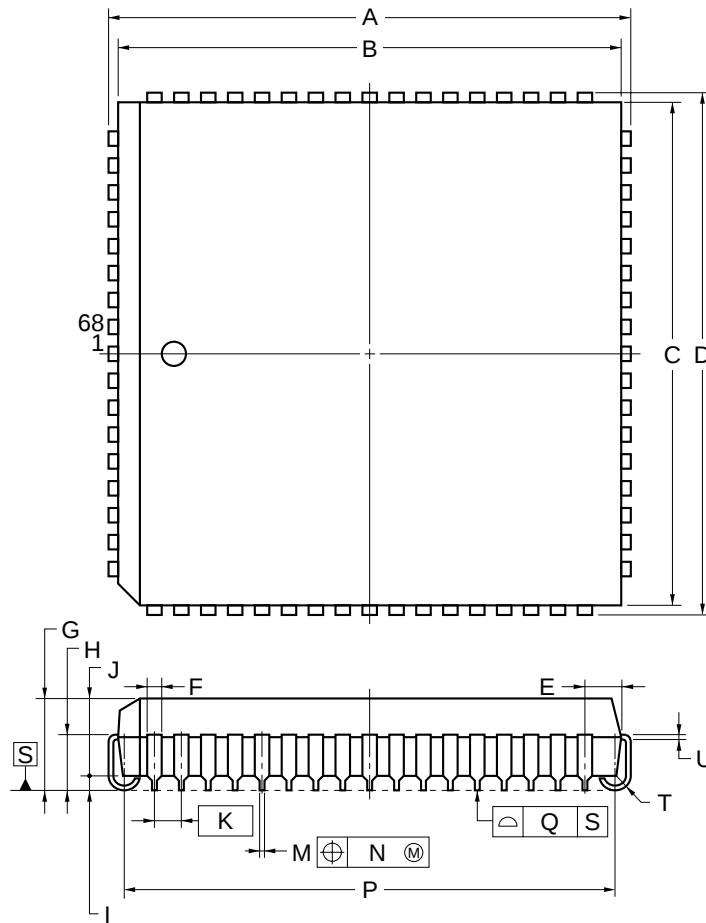
## NOTE

Each lead centerline is located within 0.10 mm (0.004 inch) of its true position (T.P.) at maximum material condition.

| ITEM | MILLIMETERS                      | INCHES                                    |
|------|----------------------------------|-------------------------------------------|
| A    | 14.0±0.2                         | 0.551±0.008                               |
| B    | 12.0±0.2                         | 0.472 <sup>+0.009</sup> <sub>-0.008</sub> |
| C    | 12.0±0.2                         | 0.472 <sup>+0.009</sup> <sub>-0.008</sub> |
| D    | 14.0±0.2                         | 0.551±0.008                               |
| F    | 1.25                             | 0.049                                     |
| G    | 1.25                             | 0.049                                     |
| H    | 0.22±0.05                        | 0.009 <sup>+0.002</sup> <sub>-0.003</sub> |
| I    | 0.10                             | 0.004                                     |
| J    | 0.5 (T.P.)                       | 0.020 (T.P.)                              |
| K    | 1.0±0.2                          | 0.039 <sup>+0.009</sup> <sub>-0.008</sub> |
| L    | 0.5±0.2                          | 0.020 <sup>+0.008</sup> <sub>-0.009</sub> |
| M    | 0.145±0.05                       | 0.006 <sup>+0.002</sup> <sub>-0.003</sub> |
| N    | 0.10                             | 0.004                                     |
| P    | 1.0±0.05                         | 0.040 <sup>+0.002</sup> <sub>-0.003</sub> |
| Q    | 0.1±0.05                         | 0.004±0.002                               |
| R    | 3° <sup>+7°</sup> <sub>-3°</sub> | 3° <sup>+7°</sup> <sub>-3°</sub>          |
| S    | 1.2 MAX.                         | 0.048 MAX.                                |

S80GK-50-9EU

## 68 PIN PLASTIC QFJ (950 x 950 mil)



## NOTES

1. Controlling dimension — millimeter.
2. Each lead centerline is located within 0.12 mm of its true position (T.P.) at maximum material condition.

| ITEM | MILLIMETERS                            | INCHES                                    |
|------|----------------------------------------|-------------------------------------------|
| A    | 25.2±0.2                               | 0.992±0.008                               |
| B    | 24.20±0.1                              | 0.953 <sup>+0.004</sup> <sub>-0.005</sub> |
| C    | 24.20±0.1                              | 0.953 <sup>+0.004</sup> <sub>-0.005</sub> |
| D    | 25.2±0.2                               | 0.992±0.008                               |
| E    | 1.94±0.15                              | 0.076 <sup>+0.007</sup> <sub>-0.006</sub> |
| F    | 0.6                                    | 0.024                                     |
| G    | 4.4±0.2                                | 0.173 <sup>+0.009</sup> <sub>-0.008</sub> |
| H    | 2.8±0.2                                | 0.110 <sup>+0.009</sup> <sub>-0.008</sub> |
| I    | 0.9 MIN.                               | 0.035 MIN.                                |
| J    | 3.4±0.1                                | 0.134 <sup>+0.004</sup> <sub>-0.005</sub> |
| K    | 1.27 (T.P.)                            | 0.050 (T.P.)                              |
| M    | 0.42±0.08                              | 0.017 <sup>+0.003</sup> <sub>-0.004</sub> |
| N    | 0.12                                   | 0.005                                     |
| P    | 23.12±0.2                              | 0.910 <sup>+0.009</sup> <sub>-0.008</sub> |
| Q    | 0.15                                   | 0.006                                     |
| T    | R 0.8                                  | R 0.031                                   |
| U    | 0.22 <sup>+0.08</sup> <sub>-0.07</sub> | 0.009 <sup>+0.003</sup> <sub>-0.004</sub> |

P68L-50A1-3

## 18. RECOMMENDED SOLDERING CONDITIONS

This product should be soldered and mounted under the conditions recommended in the table below.

For the details of recommended soldering conditions for the surface mounting type, refer to the information document **Semiconductor Device Mounting Technology Manual (C10535E)**.

For soldering methods and conditions other than those recommended below, contact our salesman.

**Table 18-1. Soldering Conditions**

(1)  $\mu$ PD70208HGF- $\times$ -3B9 : 80-pin plastic QFP (14  $\times$  20 mm)

$\mu$ PD70216HGF- $\times$ -3B9 : 80-pin plastic QFP (14  $\times$  20 mm)

(a) K, E, X masks

| Soldering Method    | Soldering Conditions                                                                                                                                                                                                                                    | Recommended Conditions Symbol |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Infrared reflow     | Package peak temperature : 230 °C, Time: 30 sec. max. (210 °C min.),<br>Number of times: 1, Number of days <sup>Note</sup> : 7 days (after this, prebaking is necessary at 125 °C for 10 hours)                                                         | IR30-107-1                    |
| VPS                 | Package peak temperature: 215 °C, Time: 40 sec. max. (200 °C min.),<br>Number of times: 1, Number of days <sup>Note</sup> : 7 days (after this, prebaking is necessary at 125 °C for 10 hours)                                                          | VP15-107-1                    |
| Wave soldering      | Solder bath temperature: 260 °C max. Time: 10 sec. max., Number of times: 1,<br>Preheating temperature: 120 °C max. (Package surface temperature), Number of days <sup>Note</sup> : 7 days (after this, prebaking is necessary at 125 °C for 10 hours). | WS60-107-1                    |
| Partial pin heating | Pin temperature: 300 °C max., Time: 3 sec. max. (per device side)                                                                                                                                                                                       | —                             |

(b) P, M masks

| Soldering Method    | Soldering Conditions                                                                                                                                                                                                                                     | Recommended Conditions Symbol |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Infrared reflow     | Package peak temperature: 235 °C, Time: 30 sec. max. (210 °C min.),<br>Number of times: 2 max., Number of days <sup>Note</sup> : 7 days (after this, prebaking is necessary at 125 °C for 20 hours).                                                     | IR35-207-2                    |
| VPS                 | Package peak temperature: 215 °C, Time: 40 sec. (200 °C min.)<br>Number of times: 2 max., Number of days <sup>Note</sup> : 7 days (after this prebaking is necessary at 125 °C for 20 hours).                                                            | VP15-207-2                    |
| Wave soldering      | Solder bath temperature: 260 °C max., Time: 10 sec. max.,<br>Number of times: 1, Preheating temperature: 120 °C max. (Package surface temperature). Number of days <sup>Note</sup> : 7 days (after this, prebaking is necessary at 125 °C for 20 hours). | WS60-207-1                    |
| Partial pin heating | Pin temperature: 300 °C max., Time: 3 sec. max. (per device side)                                                                                                                                                                                        | —                             |

**Note** This means the number of days after unpacking the dry pack. Storage conditions are 25 °C and 65% RH max.

## (c) L, F masks

| Soldering Method    | Soldering Conditions                                                                                                                               | Recommended Conditions Symbol |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Infrared reflow     | Package peak temperature: 235 °C, Time: 30 sec. max. (210 °C min.),<br>Number of times: 3 max.                                                     | IR35-00-3                     |
| VPS                 | Package peak temperature: 215 °C, Time: 40 sec. (200 °C min.)<br>Number of times: 3 max.                                                           | VP15-00-3                     |
| Wave soldering      | Solder bath temperature: 260 °C max., Time: 10 sec. max.,<br>Number of times: 1, Preheating temperature: 120 °C max. (Package surface temperature) | WS60-00-1                     |
| Partial pin heating | Pin temperature: 300 °C max., Time: 3 sec. max. (per device side)                                                                                  | —                             |

**Caution** Do not use one soldering method in combination with another. (however, partial pin heating can be performed with other soldering methods).

(2) μPD70208HGK-×-9EU : 80-pin plastic TQFP (fine pitch) (12 × 12 mm)

μPD70216HGK-×-9EU : 80-pin plastic TQFP (fine pitch) (12 × 12 mm)

(a) K, E, X masks

| Soldering Method    | Soldering Conditions                                                                                                                                                                           | Recommended Conditions Symbol |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Infrared reflow     | Package peak temperature : 230 °C, Time: 30 sec. max. (210 °C min.),<br>Number of times: 1, Number of days <sup>Note</sup> : 1 day (after this, prebaking is necessary at 125 °C for 10 hours) | IR30-101-1                    |
| VPS                 | Package peak temperature: 215 °C, Time: 40 sec. max. (200 °C min.),<br>Number of times: 1, Number of days <sup>Note</sup> : 1 day (after this, prebaking is necessary at 125 °C for 10 hours)  | VP15-101-1                    |
| Partial pin heating | Pin temperature: 300 °C max., Time: 3 sec. max. (per device side)                                                                                                                              | —                             |

(b) P, M, L, F masks

| Soldering Method | Soldering Conditions                                                                                                                                                                                 | Recommended Conditions Symbol |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Infrared reflow  | Package peak temperature: 235 °C, Time: 30 sec. max. (210 °C min.),<br>Number of times: 2 max., Number of days <sup>Note</sup> : 7 days (after this, prebaking is necessary at 125 °C for 10 hours). | IR35-107-2                    |
| VPS              | Package peak temperature: 215 °C, Time: 40 sec. (200 °C min.), Number of times: 2 max., Number of days <sup>Note</sup> : 7 days (after this prebaking is necessary at 125 °C for 10 hours).          | VP15-107-2                    |
| Partial heating  | Pin temperature: 300 °C max., Time: 3 sec. max. (per device side)                                                                                                                                    | —                             |

**Note** This means the number of days after unpacking the dry pack. Storage conditions are 25 °C and 65% RH max.

**Caution** Do not use one soldering method in combination with another. (however, partial pin heating can be performed with other soldering methods).

(3)  $\mu$ PD70208HLP- $\times$  : 68-pin plastic QFJ (950  $\times$  950 mil)

$\mu$ PD70216HLP- $\times$  : 68-pin plastic QFJ (950  $\times$  950 mil)

(a) K, E, X masks

| Soldering Method    | Soldering Conditions                                                                                                                                                                            | Recommended Conditions Symbol |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Infrared reflow     | Package peak temperature : 230 °C, Time: 30 sec. max. (210 °C min.),<br>Number of times: 1, Number of days <sup>Note</sup> : 7 days (after this, prebaking is necessary at 125 °C for 36 hours) | IR30-367-1                    |
| VPS                 | Package peak temperature: 215 °C, Time: 40 sec. max. (200 °C min.),<br>Number of times: 1, Number of days <sup>Note</sup> : 7 days (after this, prebaking is necessary at 125 °C for 36 hours)  | VP15-367-1                    |
| Partial pin heating | Pin temperature: 300 °C max., Time: 3 sec. max. (per device side)                                                                                                                               | —                             |

(b) P, M, L, F masks

| Soldering Method    | Soldering Conditions                                                                                                                                                                                 | Recommended Conditions Symbol |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Infrared reflow     | Package peak temperature: 235 °C, Time: 30 sec. max. (210 °C min.),<br>Number of times: 3 max., Number of days <sup>Note</sup> : 7 days (after this, prebaking is necessary at 125 °C for 36 hours). | IR35-367-3                    |
| VPS                 | Package peak temperature: 215 °C, Time: 40 sec. (200 °C min.),<br>Number of times: 3 max., Number of days <sup>Note</sup> : 7 days (after this prebaking is necessary at 125 °C for 36 hours).       | VP15-367-3                    |
| Partial pin heating | Pin temperature: 300 °C max., Time: 3 sec. max. (per device side)                                                                                                                                    | —                             |

**Note** This means the number of days after unpacking the dry pack. Storage conditions are 25 °C and 65% RH max.

**Caution** Do not use one soldering method in combination with another. (however, partial pin heating can be performed with other soldering methods).

[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.

## 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.

### NEC Electronics Inc. (U.S.)

Santa Clara, California  
Tel: 408-588-6000  
800-366-9782  
Fax: 408-588-6130  
800-729-9288

### NEC Electronics (Germany) GmbH

Duesseldorf, Germany  
Tel: 0211-65 03 02  
Fax: 0211-65 03 490

### NEC Electronics (UK) Ltd.

Milton Keynes, UK  
Tel: 01908-691-133  
Fax: 01908-670-290

### NEC Electronics Italiana s.r.l.

Milano, Italy  
Tel: 02-66 75 41  
Fax: 02-66 75 42 99

### NEC Electronics (Germany) GmbH

Benelux Office  
Eindhoven, The Netherlands  
Tel: 040-2445845  
Fax: 040-2444580

### NEC Electronics (France) S.A.

Velizy-Villacoublay, France  
Tel: 01-30-67 58 00  
Fax: 01-30-67 58 99

### NEC Electronics (France) S.A.

Spain Office  
Madrid, Spain  
Tel: 91-504-2787  
Fax: 91-504-2860

### NEC Electronics (Germany) GmbH

Scandinavia Office  
Taeby, Sweden  
Tel: 08-63 80 820  
Fax: 08-63 80 388

### NEC Electronics Hong Kong Ltd.

Hong Kong  
Tel: 2886-9318  
Fax: 2886-9022/9044

### NEC Electronics Hong Kong Ltd.

Seoul Branch  
Seoul, Korea  
Tel: 02-528-0303  
Fax: 02-528-4411

### NEC Electronics Singapore Pte. Ltd.

United Square, Singapore 1130  
Tel: 65-253-8311  
Fax: 65-250-3583

### NEC Electronics Taiwan Ltd.

Taipei, Taiwan  
Tel: 02-2719-2377  
Fax: 02-2719-5951

### NEC do Brasil S.A.

Electron Devices Division  
Rodovia Presidente Dutra, Km 214  
07210-902-Guarulhos-SP Brasil  
Tel: 55-11-6465-6810  
Fax: 55-11-6465-6829

[MEMO]

V20, V20HL, V30, V30HL, V40, V40HL, V50, V50HL and V series are trademarks of NEC Corporation.

- **The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.**
  - No part of this document may be copied or reproduced in any form or by any means without the prior written consent of NEC Corporation. NEC Corporation assumes no responsibility for any errors which may appear in this document.
  - NEC Corporation does not assume any liability for infringement of patents, copyrights or other intellectual property rights of third parties by or arising from use of a device described herein or any other liability arising from use of such device. No license, either express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of NEC Corporation or others.
  - Descriptions of circuits, software, and other related information in this document are provided for illustrative purposes in semiconductor product operation and application examples. The incorporation of these circuits, software, and information in the design of the customer's equipment shall be done under the full responsibility of the customer. NEC Corporation assumes no responsibility for any losses incurred by the customer or third parties arising from the use of these circuits, software, and information.
  - 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: Aircraft, 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.