

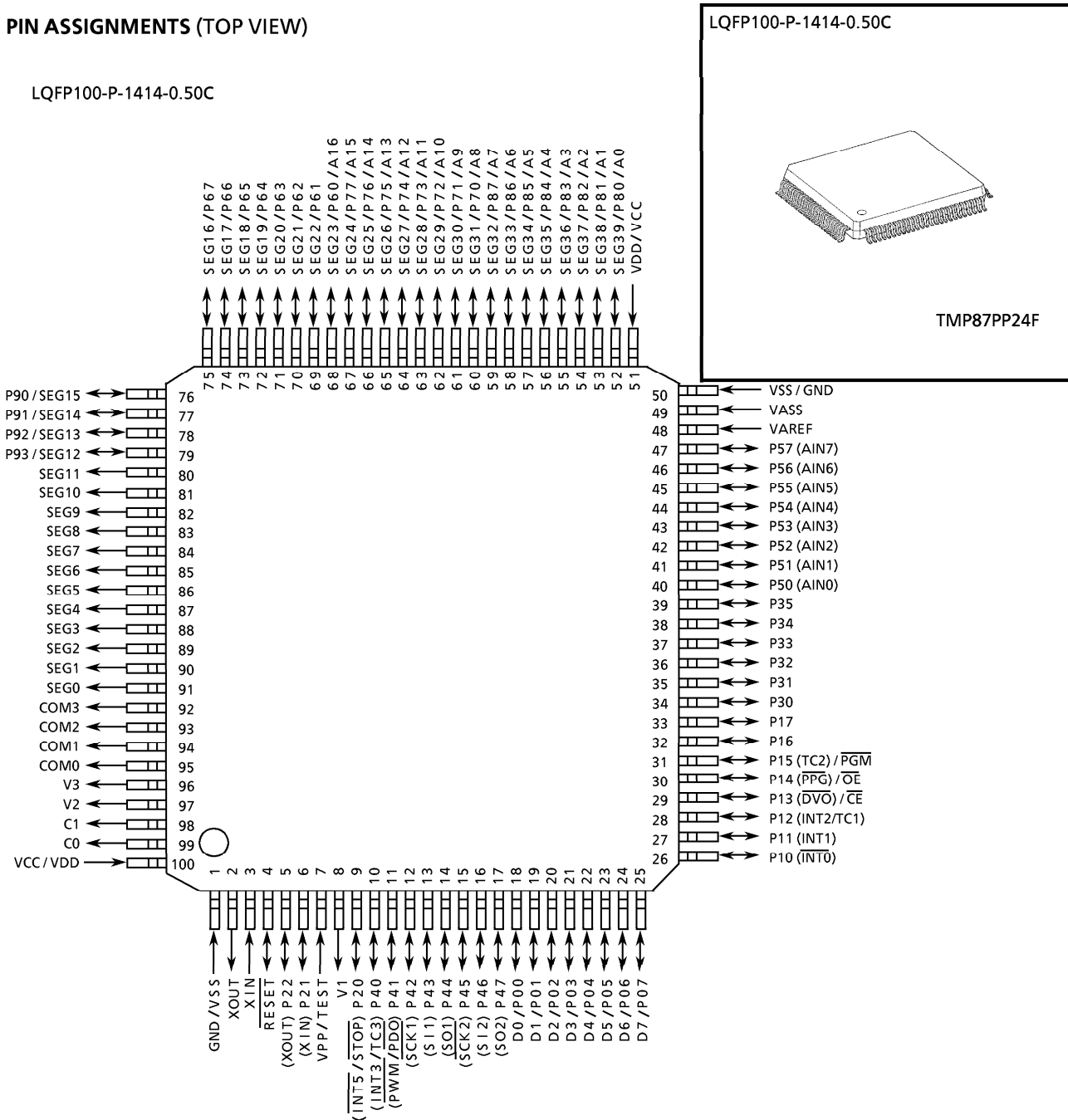
CMOS 8-BIT MICROCONTROLLER

TMP87PP24F

The 87PP24 is a One-Time PROM microcontroller with low-power 384K bits electrically programmable read only memory for the 87CM24A/CP24A system evaluation. The 87PP24 is pin compatible with the 87CM24A/CP24A. The operations possible with the 87CM24A/CP24A can be performed by writing programs to PROM. The 87PP24 can write and verify in the same way as the TMM571000D using an adaptor socket BM11127 and an EPROM programmer.

| PART No.   | OTP         | RAM        | PACKAGE              | OTP ADAPTER |
|------------|-------------|------------|----------------------|-------------|
| TMP87PP24F | 48K x 8-bit | 2K x 8-bit | LQFP100-P-1414-0.50C | BM11127     |

PIN ASSIGNMENTS (TOP VIEW)



**PIN FUNCTION**

The 87PP24 has two modes: MCU and PROM.

(1) MCU mode

In this mode, the 87PP24 is pin compatible with the 87CM24A/CP24A (fix the TEST pin at low level.)

(2) PROM mode

| PIN NAME (PROM mode) | INPUT/OUTPUT | FUNCTIONS                                      | PIN NAME (MCU mode)   |  |
|----------------------|--------------|--|---|--|
| A16                  | Input        | PROM address inputs                            | P60   |  |
| A15 to A8            |              |  | P77 to P70  |  |
| A7 to A0             |              |  | P87 to P80  |  |
| D7 to D0             | I/O          | PROM data input/outputs                        | P07 to P00  |  |
| $\overline{CE}$      | Input        | Chip enable signal input (active low)          | P13   |  |
| $\overline{OE}$      |              | Output enable signal input (active low)        | P14   |  |
| $\overline{PGM}$     |              | Program mode signal input                      | P15   |  |
| VPP                  | Power supply | + 12.75V / 5V (Program supply voltage)         | TEST  |  |
| VCC                  |              | + 6.25V / 5V                                   | VDD   |  |
| GND                  |              | 0V   | VSS   |  |
| P35 to P30           | I/O          | Pull-up with resistance for input processing.  |   |  |
| P47 to P40           |              |  |   |  |
| P57 to P50           |              |  |   |  |
| P67 to P62           |              |  |   |  |
| P93 to P90           |              |  |   |  |
| P11                  |              | PROM mode setting pin. Be fixed at high level. |   |  |
| P21                  |              |  |   |  |
| P31                  |              |  |   |  |
| P61                  |              | PROM mode setting pin. Be fixed at low level.  |   |  |
| P17, P16, P12, P10   |              |  |   |  |
| P22, P20             |              |  |   |  |
| RESET                |              |  |   |  |
| XIN                  |              | Input  | Connect an 8MHz oscillator to stabilize the internal state. |  |
| XOUT                 |              | Output   |   |  |
| VAREF                | Power supply | 0V (GND)                                       |   |  |
| VASS                 |              |  |   |  |
| COM3 to COM0         | Output       | Open   |   |  |
| SEG11 to SEG0        |              |  |   |  |
| C0, C1, V1, V2, V3   | Power supply |  |   |  |

**OPERATIONAL DESCRIPTION**

The following explains the 87PP24 hardware configuration and operation. The configuration and functions of the 87PP24 are the same as those of the 87CM24A/CP24A, except in that a one-time PROM is used instead of an on-chip mask ROM.

The 87PP24 is placed in the *single-clock* mode during reset. To use the dual-clock mode, the low-frequency oscillator should be turned on by executing [SET (SYSCR2). XTEN] instruction at the beginning of the program.

**1. OPERATING MODE**

The 87PP24 has two modes: MCU and PROM.

**1.1 MCU Mode**

The MCU mode is activated by fixing the TEST / VPP pin at low level.

In the MCU mode, operation is the same as with the 87CM24A/CP24A (the TEST / VPP pin cannot be used open because it has no built-in pull-down resistance).

**1.1.1 Program Memory**

The 87PP24 has a 48K × 8-bit (addresses 4000<sub>H</sub>-FFFF<sub>H</sub> in the MCU mode, addresses 14000<sub>H</sub>-1FFFF<sub>H</sub> in the PROM mode) of program memory (OTP).

When the 87PP24 is used as a system evaluation of the 87CM24A/CP24A, the data is written to the program storage area show in Figure 1-1.

*Note : Either write the data FF<sub>H</sub> to the unused area or set the PROM programmer to access only the program storage area.*

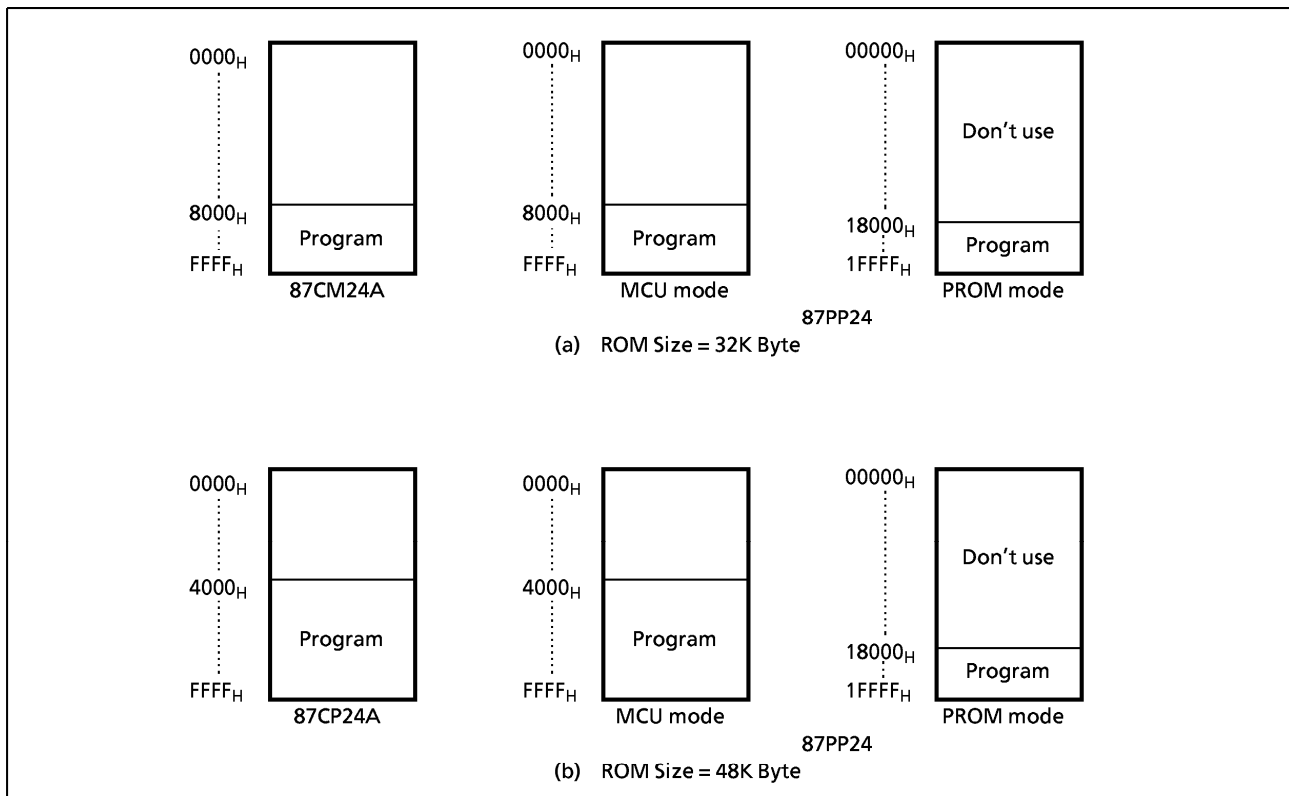


Figure 1-1. Program Memory Area

**1.1.2 Data Memory**

The 87PP24 has an on-chip 2K × 8-bit data memory (static RAM).

**1.1.3 Input/Output Circuitry**

(1) Control pins

The control pins of the 87PP24 are the same as those of the 87CM24A/CP24A except that the TEST pin has no built-in pull-down resistance.

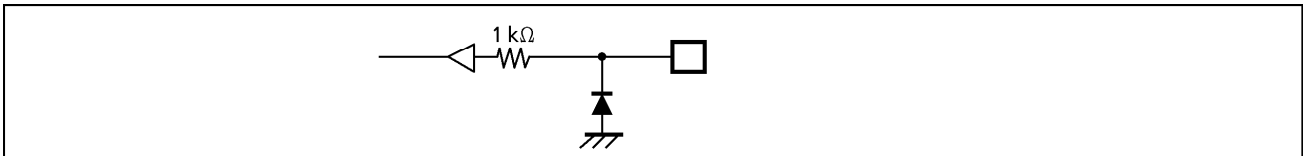


Figure 1-2. TEST Pin

(2) I/O ports

The I/O circuits of 87PP24 I/O ports are the same as the code A type I/O circuitries of the 87CM24A/CP24A. (except for I/O or segment output PORT P6, P7, P8, P9)

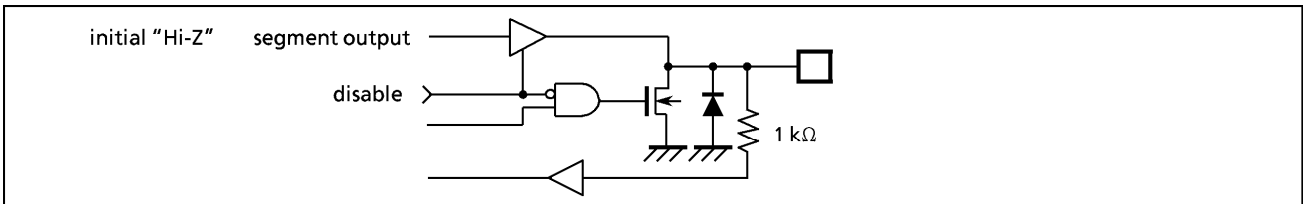


Figure 1-3. P6 to P9 port

1.2 PROM Mode

The PROM mode is activated by setting the TEST,  $\overline{\text{RESET}}$  pin and the ports P17-P10, P22-P20 and P61 as shown in Figure 1-4. The PROM mode is used to write and verify programs with a general-purpose PROM programmer.

*Note :* The high-speed programming mode can be used for program operation.  
 The 87PP24 is not supported an electric signature mode, so the ROM type must be set to TC571000D.

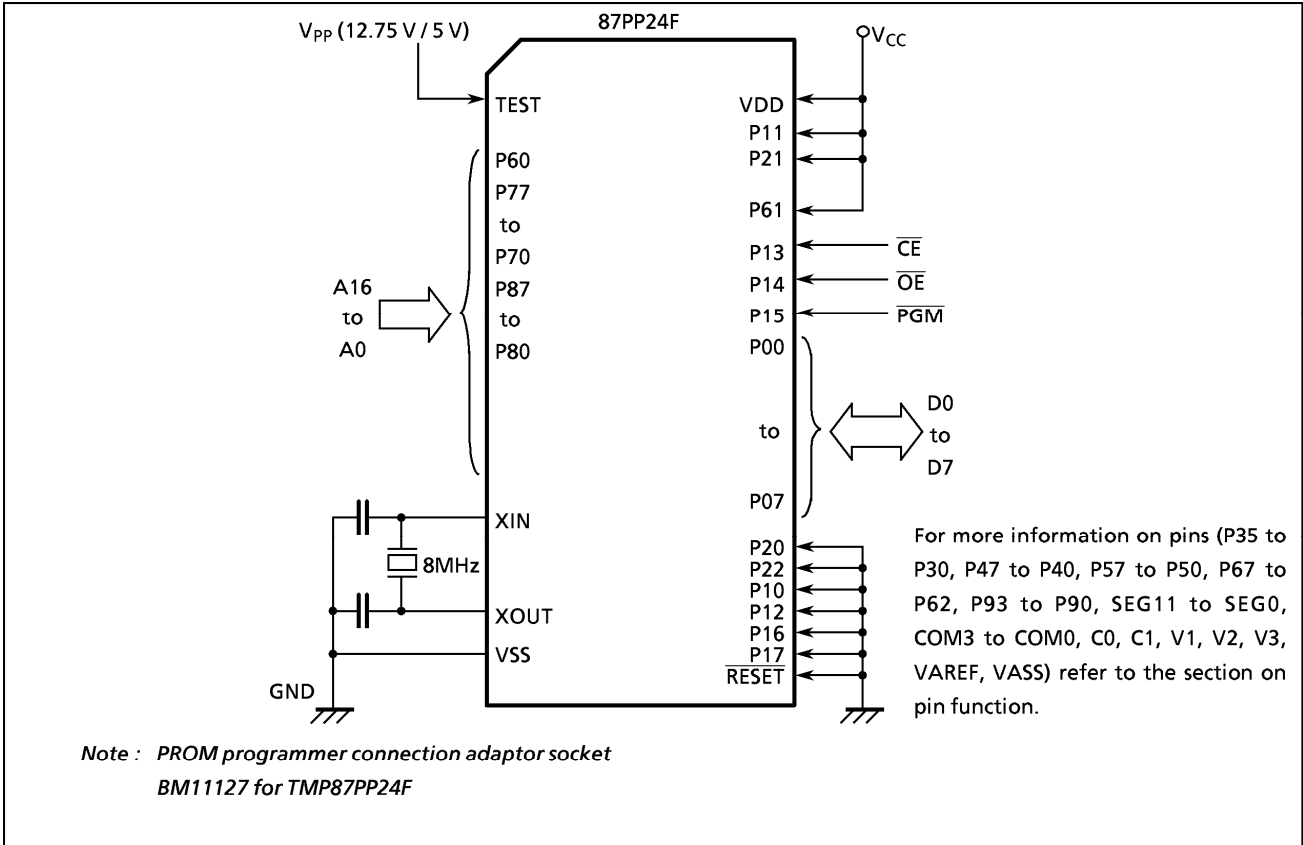


Figure 1-4. Setting for PROM Mode

1.2.1 Programming Flowchart (High-speed Programming Mode)

The high-speed programming mode is achieved by applying the program voltage (+ 12.75 V) to the VPP pin when Vcc = 6.25 V. After the address and input data are stable, the data is programmed by applying a single 0.1 ms program pulse to the PGM input. The programmed data is verified. If incorrect, another 0.1 ms program pulse is applied. This process should be repeated (up to 25 times) until the program operates correctly. After that, change the address and input data, and program as before. When programming has been completed, the data in all addresses should be verified with Vcc = Vpp = 5 V.

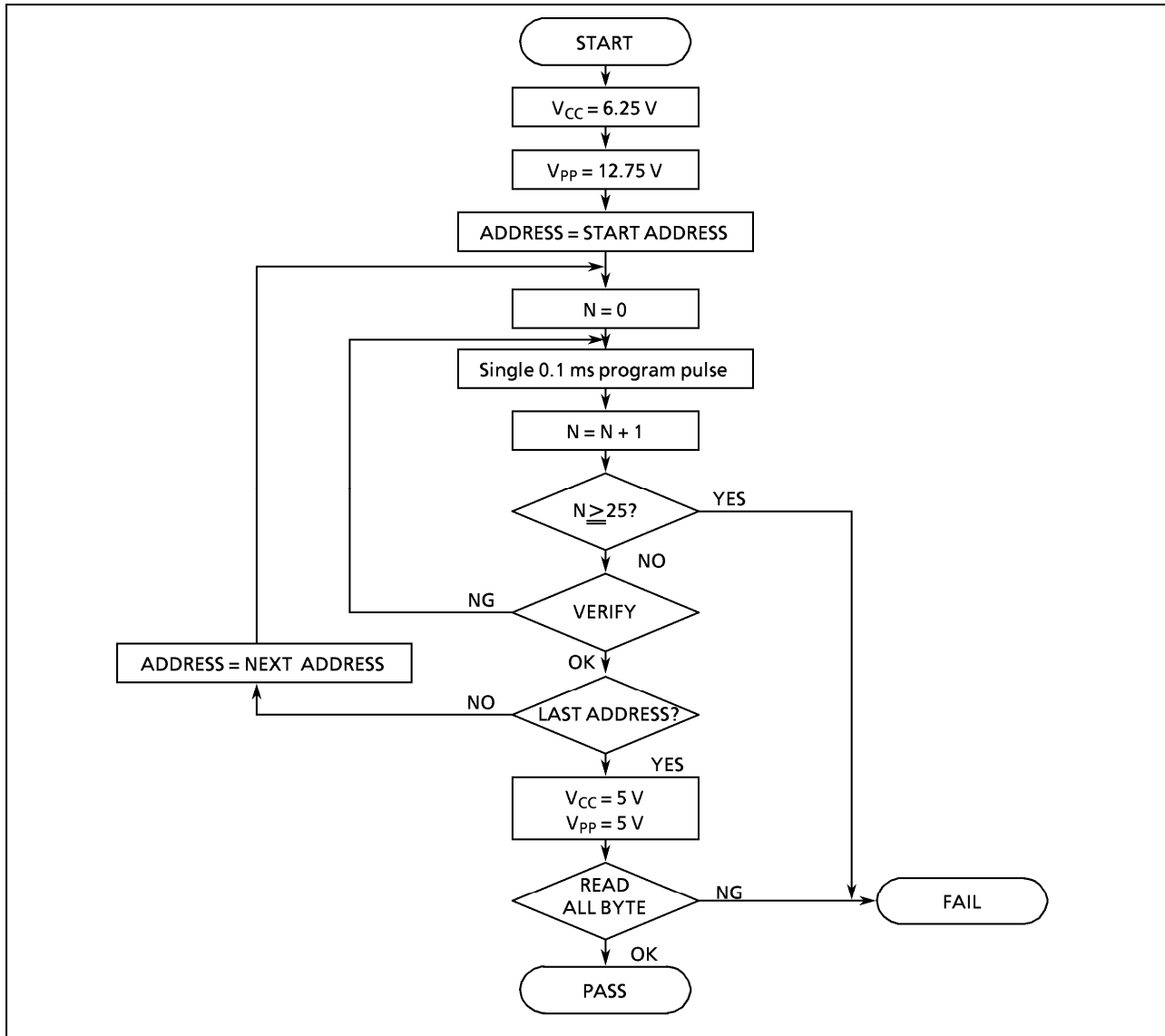


Figure 1-5. Flow Chart of High-speed Programming

## 1.2.2 Writing Method for General-purpose PROM Program

(1) Adapters

BM11127 : TMP87PP24F

(2) Adapter setting

Switch (SW1) is set to side N.

(3) PROM programmer specifying

i) PROM type is specified to TC571000D.

Writing voltage : 12.75 V (high-speed program mode)

ii) Data transfer (copy) (note 1)

In the TMP87PP24, EPROM is within the addresses 14000<sub>H</sub> to 1FFFF<sub>H</sub>. Data is required to be transferred (copied) to the addresses where it is possible to write. The program area in MCU mode and PROM mode is referred to "Program memory area" in Figure 1-1.

Ex. In the block transfer (copy) mode, executed as below.

ROM capacity of 48KB : transferred addresses 04000<sub>H</sub> to 0FFFF<sub>H</sub> to addresses 14000 to 1FFFF<sub>H</sub>

iii) Writing address is specified. (note 1)

Start address : 14000<sub>H</sub>

End address : 1FFFF<sub>H</sub>

(4) Writing

Writing/Verifying is required to be executed in accordance with PROM programmer operating procedure.

*Note 1 : The specifying method is referred to the PROM programmer description. Either write the data FF<sub>H</sub> to the unused area or set the PROM programmer to access only the program storage area.*

*Note 2 : When MCU is set to an adapter or the adapter is set to PROM programmer, a position of pin 1 must be adjusted. If the setting is reversed, MCU, the adapter and PROM program is damaged.*

*Note 3 : The TMP87PP24 does not support the electric signature mode (hereinafter referred to as "signature"). If the signature is used in PROM program, a device is damaged due to applying 12V ± 0.5V to the address pin 9 (A9). The signature must not be used.*

## ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS (V<sub>SS</sub> = 0V)

| PARAMETER                       | SYMBOL              | PINS  | RATINGS                        | UNIT |
|---------------------------------|---------------------|---|--------------------------------|------|
| Supply Voltage                  | V <sub>DD</sub>     |   | - 0.3 to 6.5                   | V    |
| Input Voltage                   | V <sub>IN</sub>     |   | - 0.3 to V <sub>DD</sub> + 0.3 | V    |
| Output Voltage                  | V <sub>OUT</sub>    |   | - 0.3 to V <sub>DD</sub> + 0.3 | V    |
| Output Current (Per 1 pin)      | I <sub>OUT1</sub>   | Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41) | 3.2                            | mA   |
|                                 | I <sub>OUT2</sub>   | P41   | 30                             |      |
| Output Current (Total)          | ∑ I <sub>OUT1</sub> | Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41) | 120                            | mA   |
|                                 | ∑ I <sub>OUT2</sub> | P41   | 30                             |      |
| Power Dissipation [Topr = 70°C] | PD                  |   | 350                            | mW   |
| Soldering Temperature (time)    | T <sub>sld</sub>    |   | 260 (10 s)                     | °C   |
| Storage Temperature             | T <sub>stg</sub>    |   | - 55 to 125                    | °C   |
| Operating Temperature           | Topr                |   | - 10 to 70                     | °C   |

RECOMMENDED OPERATING CONDITIONS (V<sub>SS</sub> = 0V, Topr = - 10 to 70°C)

| PARAMETER          | SYMBOL           | PINS                    | CONDITIONS                    | Min.                   | Max.                   | UNIT |                        |
|--------------------|------------------|-------------------------|-------------------------------|------------------------|------------------------|------|------------------------|
| Supply Voltage     | V <sub>DD</sub>  |                         | f <sub>c</sub> = 8 MHz        | NORMAL1, 2 mode        | 4.5                    | 5.5  | V                      |
|                    |                  |                         |                               | IDLE1, 2 mode          |                        |      |                        |
|                    |                  |                         | f <sub>c</sub> = 4.2 MHz      | NORMAL1, 2 mode        | 2.2                    |      |                        |
|                    |                  |                         |                               | IDLE1, 2 mode          |                        |      |                        |
|                    |                  |                         | f <sub>s</sub> = 32.768 kHz   | SLOW mode              | 2.0                    |      |                        |
| SLEEP mode         |                  |                         |                               |                        |                        |      |                        |
|                    | STOP mode        |                         |                               |                        |                        |      |                        |
| Input High Voltage | V <sub>IH1</sub> | Except hysteresis input | V <sub>DD</sub> ≥ 4.5V        | V <sub>DD</sub> × 0.70 | V <sub>DD</sub>        | V    |                        |
|                    | V <sub>IH2</sub> | Hysteresis input        |                               | V <sub>DD</sub> × 0.75 |                        |      |                        |
|                    | V <sub>IH3</sub> |                         |                               | V <sub>DD</sub> < 4.5V |                        |      | V <sub>DD</sub> × 0.90 |
| Input Low Voltage  | V <sub>IL1</sub> | Except hysteresis input | V <sub>DD</sub> ≥ 4.5V        | 0                      | V <sub>DD</sub> × 0.30 | V    |                        |
|                    | V <sub>IL2</sub> | Hysteresis input        |                               |                        | V <sub>DD</sub> × 0.25 |      |                        |
|                    | V <sub>IL3</sub> |                         |                               |                        | V <sub>DD</sub> < 4.5V |      | V <sub>DD</sub> × 0.10 |
| Clock Frequency    | f <sub>c</sub>   | XIN, XOUT               | V <sub>DD</sub> = 4.5 to 5.5V | 0.4                    | 8.0                    | MHz  |                        |
|                    |                  |                         | V <sub>DD</sub> = 2.2 to 5.5V |                        | 4.2                    |      |                        |
|                    | f <sub>s</sub>   | XTIN, XTOUT             |                               | 30.0                   | 34.0                   | kHz  |                        |

Note : Clock frequency f<sub>c</sub> : Supply voltage range is specified in NORMAL1/2 mode and IDLE1/2 mode.



## 1.2.2 Writing Method for General-purpose PROM Program

(1) Adapters

BM11127 : TMP87PP24F

(2) Adapter setting

Switch (SW1) is set to side N.

(3) PROM programmer specifying

i) PROM type is specified to TC571000D.

Writing voltage : 12.75 V (high-speed program mode)

ii) Data transfer (copy) (note 1)

In the TMP87PP24, EPROM is within the addresses 14000<sub>H</sub> to 1FFFF<sub>H</sub>. Data is required to be transferred (copied) to the addresses where it is possible to write. The program area in MCU mode and PROM mode is referred to "Program memory area" in Figure 1-1.

Ex. In the block transfer (copy) mode, executed as below.

ROM capacity of 48KB : transferred addresses 04000<sub>H</sub> to 0FFFF<sub>H</sub> to addresses 14000 to 1FFFF<sub>H</sub>

iii) Writing address is specified. (note 1)

Start address : 14000<sub>H</sub>

End address : 1FFFF<sub>H</sub>

(4) Writing

Writing/Verifying is required to be executed in accordance with PROM programmer operating procedure.

*Note 1 : The specifying method is referred to the PROM programmer description. Either write the data FF<sub>H</sub> to the unused area or set the PROM programmer to access only the program storage area.*

*Note 2 : When MCU is set to an adapter or the adapter is set to PROM programmer, a position of pin 1 must be adjusted. If the setting is reversed, MCU, the adapter and PROM program is damaged.*

*Note 3 : The TMP87PP24 does not support the electric signature mode (hereinafter referred to as "signature"). If the signature is used in PROM program, a device is damaged due to applying 12V ± 0.5V to the address pin 9 (A9). The signature must not be used.*

## ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS (V<sub>SS</sub> = 0V)

| PARAMETER                       | SYMBOL              | PINS  | RATINGS                        | UNIT |
|---------------------------------|---------------------|---|--------------------------------|------|
| Supply Voltage                  | V <sub>DD</sub>     |   | - 0.3 to 6.5                   | V    |
| Input Voltage                   | V <sub>IN</sub>     |   | - 0.3 to V <sub>DD</sub> + 0.3 | V    |
| Output Voltage                  | V <sub>OUT</sub>    |   | - 0.3 to V <sub>DD</sub> + 0.3 | V    |
| Output Current (Per 1 pin)      | I <sub>OUT1</sub>   | Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41) | 3.2                            | mA   |
|                                 | I <sub>OUT2</sub>   | P41   | 30                             |      |
| Output Current (Total)          | ∑ I <sub>OUT1</sub> | Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41) | 120                            | mA   |
|                                 | ∑ I <sub>OUT2</sub> | P41   | 30                             |      |
| Power Dissipation [Topr = 70°C] | PD                  |   | 350                            | mW   |
| Soldering Temperature (time)    | T <sub>sld</sub>    |   | 260 (10 s)                     | °C   |
| Storage Temperature             | T <sub>stg</sub>    |   | - 55 to 125                    | °C   |
| Operating Temperature           | Topr                |   | - 10 to 70                     | °C   |

RECOMMENDED OPERATING CONDITIONS (V<sub>SS</sub> = 0V, Topr = - 10 to 70°C)

| PARAMETER          | SYMBOL           | PINS                    | CONDITIONS                    | Min.                   | Max.                   | UNIT |                        |
|--------------------|------------------|-------------------------|-------------------------------|------------------------|------------------------|------|------------------------|
| Supply Voltage     | V <sub>DD</sub>  |                         | f <sub>c</sub> = 8 MHz        | NORMAL1, 2 mode        | 4.5                    | 5.5  | V                      |
|                    |                  |                         |                               | IDLE1, 2 mode          |                        |      |                        |
|                    |                  |                         | f <sub>c</sub> = 4.2 MHz      | NORMAL1, 2 mode        | 2.2                    |      |                        |
|                    |                  |                         |                               | IDLE1, 2 mode          |                        |      |                        |
|                    |                  |                         | f <sub>s</sub> = 32.768 kHz   | SLOW mode              | 2.0                    |      |                        |
| SLEEP mode         |                  |                         |                               |                        |                        |      |                        |
|                    |                  | STOP mode               | 2.0                           |                        |                        |      |                        |
| Input High Voltage | V <sub>IH1</sub> | Except hysteresis input | V <sub>DD</sub> ≥ 4.5V        | V <sub>DD</sub> × 0.70 | V <sub>DD</sub>        | V    |                        |
|                    | V <sub>IH2</sub> | Hysteresis input        |                               | V <sub>DD</sub> × 0.75 |                        |      |                        |
|                    | V <sub>IH3</sub> |                         |                               | V <sub>DD</sub> < 4.5V |                        |      | V <sub>DD</sub> × 0.90 |
| Input Low Voltage  | V <sub>IL1</sub> | Except hysteresis input | V <sub>DD</sub> ≥ 4.5V        | 0                      | V <sub>DD</sub> × 0.30 | V    |                        |
|                    | V <sub>IL2</sub> | Hysteresis input        |                               |                        | V <sub>DD</sub> × 0.25 |      |                        |
|                    | V <sub>IL3</sub> |                         |                               |                        | V <sub>DD</sub> < 4.5V |      | V <sub>DD</sub> × 0.10 |
| Clock Frequency    | f <sub>c</sub>   | XIN, XOUT               | V <sub>DD</sub> = 4.5 to 5.5V | 0.4                    | 8.0                    | MHz  |                        |
|                    |                  |                         | V <sub>DD</sub> = 2.2 to 5.5V |                        | 4.2                    |      |                        |
|                    | f <sub>s</sub>   | XTIN, XTOUT             |                               | 30.0                   | 34.0                   | kHz  |                        |

Note : Clock frequency f<sub>c</sub> : Supply voltage range is specified in NORMAL1/2 mode and IDLE1/2 mode.

## D.C. CHARACTERISTICS

(V<sub>SS</sub> = 0V, T<sub>opr</sub> = -10 to 70 °C)

| PARAMETER                          | SYMBOL            | PINS                                 | CONDITIONS   | Min.                  | Typ. | Max. | UNIT |
|------------------------------------|-------------------|--------------------------------------|--|-----------------------|------|------|------|
| Hysteresis Voltage                 | V <sub>HS</sub>   | Hysteresis inputs                    |  | —                     | 0.9  | —    | V    |
| Input Current                      | I <sub>IN1</sub>  | TEST                                 | V <sub>DD</sub> = 5.5V,<br>V <sub>IN</sub> = 5.5V/0V   | —                     | —    | ± 2  | μA   |
|                                    | I <sub>IN2</sub>  | Open drain ports and tri-state ports |  |                       |      |      |      |
|                                    | I <sub>IN3</sub>  | RESET, STOP                          |  |                       |      |      |      |
| Input Resistance                   | R <sub>IN2</sub>  | RESET                                |  | 100                   | 220  | 450  | kΩ   |
| Output Leakage Current             | I <sub>LO1</sub>  | Open drain ports                     | V <sub>DD</sub> = 5.5V, V <sub>OUT</sub> = 5.5V  | —                     | —    | 2    | μA   |
|                                    | I <sub>LO2</sub>  | Tri-state ports                      | V <sub>OUT</sub> = 5.5V/0V   | —                     | —    | ± 2  |      |
| Segment/Common Output Voltage      | V <sub>LCD1</sub> | SEG39-SEG0 and COM3-COM0             |  | 0.75                  | 1.0  | 1.33 | V    |
|                                    | V <sub>LCD2</sub> |                                      |  | V <sub>LCD1</sub> × 2 |      |      |      |
|                                    | V <sub>LCD3</sub> |                                      |  | V <sub>LCD2</sub> × 3 |      |      |      |
| Output High Voltage                | V <sub>OH1</sub>  | Push-pull ports P4 port              | V <sub>DD</sub> = 4.5V, I <sub>OH</sub> = -200 μA  | 2.4                   | —    | —    | V    |
|                                    | V <sub>OH2</sub>  | Tri-state ports P0, P1, P5 port      | V <sub>DD</sub> = 4.5V, I <sub>OH</sub> = -0.7 mA  | 4.1                   | —    | —    |      |
| Output Low Voltage                 | V <sub>OL</sub>   | Except XOUT and P41                  | V <sub>DD</sub> = 4.5V, I <sub>OL</sub> = 1.6 mA   | —                     | —    | 0.4  | V    |
| Output Low Current                 | I <sub>OL3</sub>  | P41                                  | V <sub>DD</sub> = 4.5V, V <sub>OL</sub> = 1.0V   | —                     | 20   | —    | mA   |
| Supply Current in NORMAL 1, 2 mode | I <sub>DD</sub>   |                                      | V <sub>DD</sub> = 5.5V<br>f <sub>c</sub> = 8 MHz<br>f <sub>s</sub> = 32.768 kHz<br>V <sub>IN</sub> = 5.3V/0.2V | —                     | 12   | 18   | mA   |
| Supply Current in IDLE 1, 2 mode   |                   |                                      |  | —                     | 6    | 10   |      |
| Supply Current in SLOW mode        |                   |                                      | V <sub>DD</sub> = 3.0V<br>f <sub>s</sub> = 32.768 kHz<br>V <sub>IN</sub> = 2.8V/0.2V                           | —                     | 31   | 70   | μA   |
| Supply Current in SLEEP mode       |                   |                                      | Voltage boost frequency = 1 kHz  | —                     | 16   | 40   | μA   |
| Supply Current in STOP mode        |                   |                                      | V <sub>DD</sub> = 5.5V<br>V <sub>IN</sub> = 5.3V/0.2V  | —                     | 0.5  | 10   | μA   |

Note 1: Typical values show those at T<sub>opr</sub> = 25 °C, V<sub>DD</sub> = 5V.

Note 2: Input Current; The current through pull-up or pull-down resistor is not included.

Note 3: I<sub>DD</sub>; Except for I<sub>REF</sub>

Note 4: V<sub>LCD2</sub> indicates an output voltage at the 2/3 level when operating in the 1/4 or 1/3 duty mode.

Note 5: V<sub>LCD1</sub> indicates an output voltage at the 1/3 level when operating in the 1/4 or 1/3 duty mode.

## A / D CONVERSION CHARACTERISTICS (I)

 $(V_{SS} = 0V, V_{DD} = 2.7 \text{ to } 5.5V, T_{opr} = -10 \text{ to } 70^\circ\text{C})$ 

| PARAMETER                | SYMBOL     | CONDITIONS   | Min       | Typ. | Max.       | UNIT |
|--------------------------|------------|--|-----------|------|------------|------|
| Analog Reference Voltage | $V_{AREF}$ |  | 2.7       | —    | $V_{DD}$   | V    |
|                          | $V_{ASS}$  |  | $V_{SS}$  | —    | 1.5        |      |
| Analog Input Voltage     | $V_{AIN}$  |  | $V_{ASS}$ | —    | $V_{AREF}$ | V    |
| Analog Supply Current    | $I_{REF}$  | $V_{AREF} = 5.5V, V_{ASS} = 0.0V$  | —         | 0.5  | 1.0        | mA   |
| Nonlinearity Error       |            | $V_{DD} = 5.0V, V_{SS} = 0.0V$<br>$V_{AREF} = 5.000V$<br>$V_{ASS} = 0.000V$<br>or<br>$V_{DD} = 2.7V, V_{SS} = 0.0V$<br>$V_{AREF} = 2.700V$<br>$V_{ASS} = 0.000V$ | —         | —    | $\pm 1$    | LSB  |
| Zero Point Error         |            |  | —         | —    | $\pm 1$    |      |
| Full Scale Error         |            |  | —         | —    | $\pm 1$    |      |
| Total Error              |            |  | —         | —    | $\pm 2$    |      |

Note : Quantizing error is not contained in those errors.

## A / D CONVERSION CHARACTERISTICS (II)

 $(V_{SS} = 0V, V_{DD} = 2.2 \text{ to } 2.7V, T_{opr} = -10 \text{ to } 70^\circ\text{C})$ 

| PARAMETER                      | SYMBOL            | CONDITIONS  | Min       | Typ. | Max.       | UNIT |
|--------------------------------|-------------------|---|-----------|------|------------|------|
| Analog Reference Voltage       | $V_{AREF}$        |   | 2.2       | —    | $V_{DD}$   | V    |
|                                | $V_{ASS}$         |   | $V_{SS}$  |      |            |      |
| Analog Reference Voltage Range | $\Delta V_{AREF}$ |   | 2.2       | —    | —          | V    |
| Analog Input Voltage           | $V_{AIN}$         |   | $V_{ASS}$ | —    | $V_{AREF}$ | V    |
| Analog Supply Current          | $I_{REF}$         | $V_{AREF} = 5.5V, V_{ASS} = 0.0V$   | —         | 0.5  | 1.0        | mA   |
| Nonlinearity Error             |                   | $V_{DD} = 2.2V, V_{SS} = 0.0V$<br>$V_{AREF} = 2.200V$<br>$V_{ASS} = 0.000V$ | —         | —    | $\pm 2$    | LSB  |
| Zero Point Error               |                   |   | —         | —    | $\pm 2$    |      |
| Full Scale Error               |                   |   | —         | —    | $\pm 2$    |      |
| Total Error                    |                   |   | —         | —    | $\pm 4$    |      |

Note : Quantizing error is not contained in those errors.

**A.C. CHARACTERISTICS ( I )** ( $V_{SS} = 0V, V_{DD} = 4.5 \text{ to } 5.5V, T_{opr} = -10 \text{ to } 70^\circ\text{C}$ )

| PARAMETER                    | SYMBOL    | CONDITIONS   | Min.  | Typ. | Max.  | UNIT          |
|------------------------------|-----------|--|-------|------|-------|---------------|
| Machine Cycle Time           | $t_{cy}$  | In NORMAL 1, 2 mode  | 0.5   | —    | 10    | $\mu\text{s}$ |
|                              |           | In IDLE 1, 2 mode  |       |      |       |               |
|                              |           | In SLOW mode   | 117.6 | —    | 133.3 |               |
|                              |           | In SLEEP mode  |       |      |       |               |
| High Level Clock Pulse Width | $t_{WCH}$ | For external clock operation<br>(XIN input), $f_c = 8 \text{ MHz}$       | 62.5  | —    | —     | ns            |
| Low Level Clock Pulse Width  | $t_{WCL}$ |  |       |      |       |               |
| High Level Clock Pulse Width | $t_{WSH}$ | For external clock operation<br>(XTIN input), $f_s = 32.768 \text{ kHz}$ | 14.7  | —    | —     | $\mu\text{s}$ |
| Low Level Clock Pulse Width  | $t_{WSL}$ |  |       |      |       |               |

**A.C. CHARACTERISTICS (II)** ( $V_{SS} = 0V, V_{DD} = 2.2 \text{ to } 5.5V, T_{opr} = -10 \text{ to } 70^\circ\text{C}$ )

| PARAMETER                    | SYMBOL    | CONDITIONS   | Min.  | Typ. | Max.  | UNIT          |
|------------------------------|-----------|--|-------|------|-------|---------------|
| Machine Cycle Time           | $t_{cy}$  | In NORMAL 1, 2 mode  | 0.95  | —    | 10    | $\mu\text{s}$ |
|                              |           | In IDLE 1, 2 mode  |       |      |       |               |
|                              |           | In SLOW mode   | 117.6 | —    | 133.3 |               |
|                              |           | In SLEEP mode  |       |      |       |               |
| High Level Clock Pulse Width | $t_{WCH}$ | For external clock operation<br>(XIN input), $f_c = 4.2 \text{ MHz}$     | 110   | —    | —     | ns            |
| Low Level Clock Pulse Width  | $t_{WCL}$ |  |       |      |       |               |
| High Level Clock Pulse Width | $t_{WSH}$ | For external clock operation<br>(XTIN input), $f_s = 32.768 \text{ kHz}$ | 14.7  | —    | —     | $\mu\text{s}$ |
| Low Level Clock Pulse Width  | $t_{WSL}$ |  |       |      |       |               |

RECOMENDED OSCILLATING CONDITION ( I )

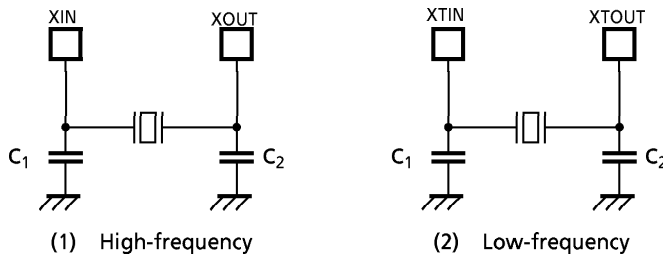
(V<sub>SS</sub> = 0V, V<sub>DD</sub> = 4.5 to 5.5V, Topr = - 10 to 70 °C)

| PARAMETER      | OSILLATOR          | FREQUENCY  | RECOMMENDER OSCILLATOR           |                          | RECOMMENDED CONDITION |                  |
|----------------|--------------------|------------|----------------------------------|--------------------------|-----------------------|------------------|
|                |                    |            |                                  |                          | C <sub>1</sub>        | C <sub>2</sub>   |
| High-frequency | Ceramic Resonator  | 8 MHz      | KYOCERA                          | KBR8.0M                  | 30pF                  | 30pF             |
|                |                    |            | Standard/Lead Type (MURATA)      | CSA8.00MTZ<br>CST8.00MTW | built-in<br>30pF      | built-in<br>30pF |
|                |                    |            | Standard/SMP Type (MURATA)       | CSAC8.00MT               | 30pF                  | 30pF             |
|                |                    |            | Standard/Small ChipType (MURATA) | CSTC8.00MT               | built-in<br>30pF      | built-in<br>30pF |
|                |                    | 4 MHz      | KYOCERA                          | KBR4.0MS                 | 30pF                  | 30pF             |
|                | Crystal Oscillator | 8 MHz      | TOYOCOM                          | 210B 8.0000              | 20pF                  | 20pF             |
|                | 4 MHz              | TOYOCOM    | 204B 4.0000                      |                          |                       |                  |
| Low-frequency  | Crystal Oscillator | 32.768 kHz | NDK                              | MX-38T                   | 15pF                  | 15pF             |

RECOMENDED OSCILLATING CONDITION ( II )

(V<sub>SS</sub> = 0V, V<sub>DD</sub> = 2.2 to 5.5V, Topr = - 10 to 70 °C)

| PARAMETER      | OSILLATOR         | FREQUENCY | RECOMMENDER OSCILLATOR      |  | RECOMMENDED CONDITION    |                          |
|----------------|-------------------|-----------|-----------------------------|--|--------------------------|--------------------------|
|                |                   |           |                             |  | C <sub>1</sub>           | C <sub>2</sub>           |
| High-frequency | Ceramic Resonator | 4 MHz     | Standard/Lead Type (MURATA) | CSA4.00MG<br>CST4.00MGW                  | 30pF<br>built-in<br>30pF | 30pF<br>built-in<br>30pF |
|                |                   |           | Standard/SMD Type (MURATA)  | CSA4.00MGC<br>CSAC4.00MGCM<br>CSTC4.00MG | 30pF<br>built-in<br>30pF | 30pF<br>built-in<br>30pF |
|                |                   |           | Standard/Small Chip Type    | CSTCS4.00MG                              | built-in<br>10pF         | built-in<br>10pF         |



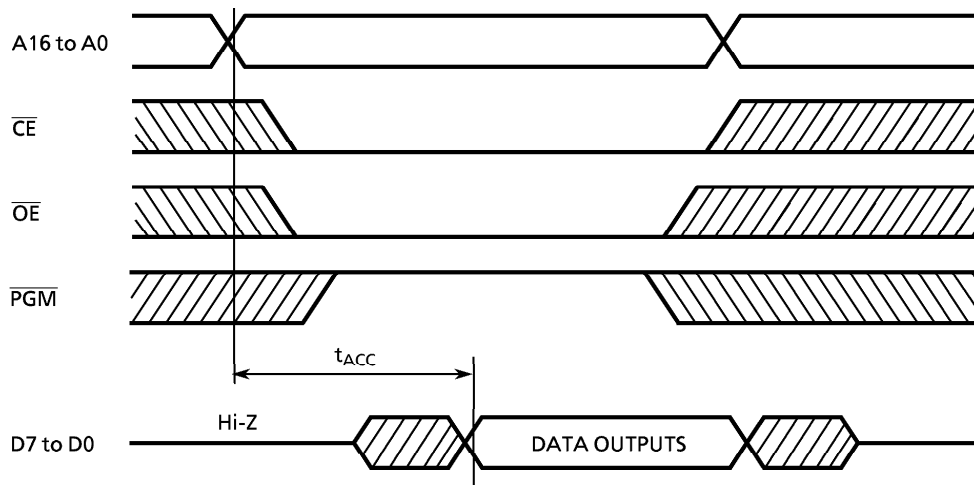
Note : When used in high electric field such as a picture tube, the package is recommended to be electrically shielded to maintain a regular operation.

D.C./A.C. CHARACTERISTICS (PROM mode) ( $V_{SS} = 0V$ )

(1) Read Operation

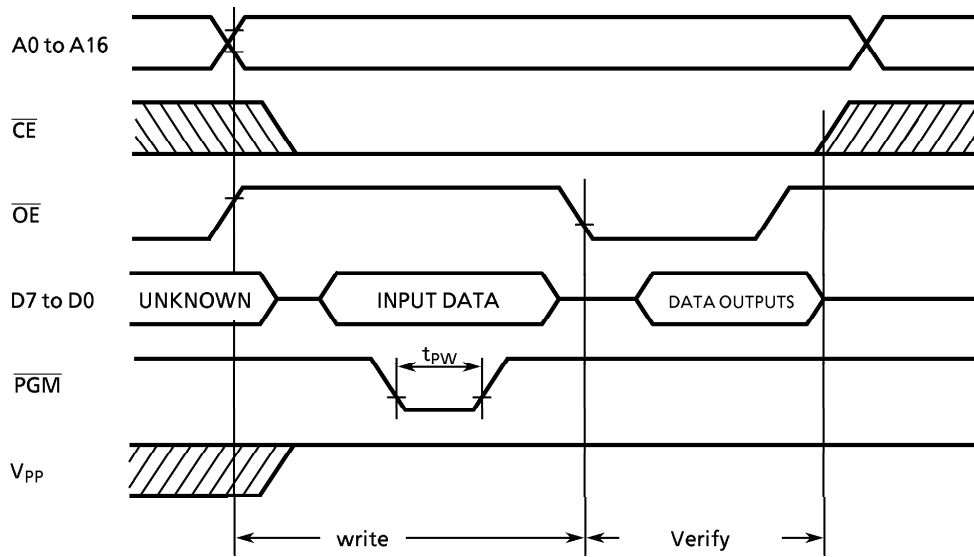
| PARAMETER                    | SYMBOL    | CONDITIONS               | Min.                | Typ.               | Max.                 | UNIT |
|------------------------------|-----------|--------------------------|---------------------|--------------------|----------------------|------|
| Input High Voltage           | $V_{IH4}$ |                          | $V_{CC} \times 0.7$ | —                  | $V_{CC}$             | V    |
| Input Low Voltage            | $V_{IL4}$ |                          | 0                   | —                  | $V_{CC} \times 0.12$ | V    |
| Power Supply Voltage         | $V_{CC}$  |                          | 4.75                | 5.0                | 5.25                 | V    |
| Program Power Supply Voltage | $V_{PP}$  |                          |                     |                    |                      | V    |
| Address Access Time          | $t_{ACC}$ | $V_{CC} = 5.0 \pm 0.25V$ | —                   | $1.5t_{cyc} + 300$ | —                    | ns   |

(Note)  $t_{cyc} = 500$  ns at 8 MHz



(2) High-Speed Programming Operation ( $T_{opr} = 25 \pm 5^\circ C$ )

| PARAMETER                    | SYMBOL    | CONDITIONS      | Min.                | Typ.  | Max.                 | UNIT |
|------------------------------|-----------|-----------------|---------------------|-------|----------------------|------|
| Input High Voltage           | $V_{IH4}$ |                 | $V_{CC} \times 0.7$ | —     | $V_{CC}$             | V    |
| Input Low Voltage            | $V_{IL4}$ |                 | 0                   | —     | $V_{CC} \times 0.12$ | V    |
| Power Supply Voltage         | $V_{CC}$  |                 | 6.0                 | 6.25  | 6.5                  | V    |
| Program Power Supply Voltage | $V_{PP}$  |                 | 12.5                | 12.75 | 13.0                 | V    |
| Initial Program Pulse Width  | $t_{PW}$  | $V_{CC} = 6.0V$ | 0.095               | 0.1   | 0.105                | ms   |



- Note 1 :** When  $V_{CC}$  power supply is turned on or after,  $V_{pp}$  must be increased.  
 When  $V_{CC}$  power supply is turned off or before,  $V_{pp}$  must be increased.
- Note 2 :** The device must not be set to the EPROM programmer or picked up from it under applying the program voltage ( $12.5V \pm 0.5v = V$ ) to the  $V_{pp}$  pin as the device is damaged.
- Note 3 :** Be sure to execute the recommended programing mode with the recommended programing adaptor. If a mode or an adaptor except the above, the misoperation sometimes occurs.



## D.C. CHARACTERISTICS

(V<sub>SS</sub> = 0V, T<sub>opr</sub> = -10 to 70 °C)

| PARAMETER                          | SYMBOL            | PINS                                 | CONDITIONS   | Min.                  | Typ. | Max. | UNIT |
|------------------------------------|-------------------|--------------------------------------|--|-----------------------|------|------|------|
| Hysteresis Voltage                 | V <sub>HS</sub>   | Hysteresis inputs                    |  | —                     | 0.9  | —    | V    |
| Input Current                      | I <sub>IN1</sub>  | TEST                                 | V <sub>DD</sub> = 5.5V,<br>V <sub>IN</sub> = 5.5V/0V   | —                     | —    | ± 2  | μA   |
|                                    | I <sub>IN2</sub>  | Open drain ports and tri-state ports |  |                       |      |      |      |
|                                    | I <sub>IN3</sub>  | RESET, STOP                          |  |                       |      |      |      |
| Input Resistance                   | R <sub>IN2</sub>  | RESET                                |  | 100                   | 220  | 450  | kΩ   |
| Output Leakage Current             | I <sub>LO1</sub>  | Open drain ports                     | V <sub>DD</sub> = 5.5V, V <sub>OUT</sub> = 5.5V  | —                     | —    | 2    | μA   |
|                                    | I <sub>LO2</sub>  | Tri-state ports                      | V <sub>OUT</sub> = 5.5V/0V   | —                     | —    | ± 2  |      |
| Segment/Common Output Voltage      | V <sub>LCD1</sub> | SEG39-SEG0 and COM3-COM0             |  | 0.75                  | 1.0  | 1.33 | V    |
|                                    | V <sub>LCD2</sub> |                                      |  | V <sub>LCD1</sub> × 2 |      |      |      |
|                                    | V <sub>LCD3</sub> |                                      |  | V <sub>LCD2</sub> × 3 |      |      |      |
| Output High Voltage                | V <sub>OH1</sub>  | Push-pull ports P4 port              | V <sub>DD</sub> = 4.5V, I <sub>OH</sub> = -200 μA  | 2.4                   | —    | —    | V    |
|                                    | V <sub>OH2</sub>  | Tri-state ports P0, P1, P5 port      | V <sub>DD</sub> = 4.5V, I <sub>OH</sub> = -0.7 mA  | 4.1                   | —    | —    |      |
| Output Low Voltage                 | V <sub>OL</sub>   | Except XOUT and P41                  | V <sub>DD</sub> = 4.5V, I <sub>OL</sub> = 1.6 mA   | —                     | —    | 0.4  | V    |
| Output Low Current                 | I <sub>OL3</sub>  | P41                                  | V <sub>DD</sub> = 4.5V, V <sub>OL</sub> = 1.0V   | —                     | 20   | —    | mA   |
| Supply Current in NORMAL 1, 2 mode | I <sub>DD</sub>   |                                      | V <sub>DD</sub> = 5.5V<br>f <sub>c</sub> = 8 MHz<br>f <sub>s</sub> = 32.768 kHz<br>V <sub>IN</sub> = 5.3V/0.2V | —                     | 12   | 18   | mA   |
| Supply Current in IDLE 1, 2 mode   |                   |                                      |  | —                     | 6    | 10   |      |
| Supply Current in SLOW mode        |                   |                                      | V <sub>DD</sub> = 3.0V<br>f <sub>s</sub> = 32.768 kHz<br>V <sub>IN</sub> = 2.8V/0.2V                           | —                     | 31   | 70   | μA   |
| Supply Current in SLEEP mode       |                   |                                      | Voltage boost frequency = 1 kHz  | —                     | 16   | 40   | μA   |
| Supply Current in STOP mode        |                   |                                      | V <sub>DD</sub> = 5.5V<br>V <sub>IN</sub> = 5.3V/0.2V  | —                     | 0.5  | 10   | μA   |

Note 1: Typical values show those at T<sub>opr</sub> = 25 °C, V<sub>DD</sub> = 5V.

Note 2: Input Current; The current through pull-up or pull-down resistor is not included.

Note 3: I<sub>DD</sub>; Except for I<sub>REF</sub>

Note 4: V<sub>LCD2</sub> indicates an output voltage at the 2/3 level when operating in the 1/4 or 1/3 duty mode.

Note 5: V<sub>LCD1</sub> indicates an output voltage at the 1/3 level when operating in the 1/4 or 1/3 duty mode.

## A / D CONVERSION CHARACTERISTICS (I)

 $(V_{SS} = 0V, V_{DD} = 2.7 \text{ to } 5.5V, T_{opr} = -10 \text{ to } 70^\circ\text{C})$ 

| PARAMETER                | SYMBOL     | CONDITIONS   | Min       | Typ. | Max.       | UNIT |
|--------------------------|------------|--|-----------|------|------------|------|
| Analog Reference Voltage | $V_{AREF}$ |  | 2.7       | —    | $V_{DD}$   | V    |
|                          | $V_{ASS}$  |  | $V_{SS}$  | —    | 1.5        |      |
| Analog Input Voltage     | $V_{AIN}$  |  | $V_{ASS}$ | —    | $V_{AREF}$ | V    |
| Analog Supply Current    | $I_{REF}$  | $V_{AREF} = 5.5V, V_{ASS} = 0.0V$  | —         | 0.5  | 1.0        | mA   |
| Nonlinearity Error       |            | $V_{DD} = 5.0V, V_{SS} = 0.0V$<br>$V_{AREF} = 5.000V$<br>$V_{ASS} = 0.000V$<br>or<br>$V_{DD} = 2.7V, V_{SS} = 0.0V$<br>$V_{AREF} = 2.700V$<br>$V_{ASS} = 0.000V$ | —         | —    | $\pm 1$    | LSB  |
| Zero Point Error         |            |  | —         | —    | $\pm 1$    |      |
| Full Scale Error         |            |  | —         | —    | $\pm 1$    |      |
| Total Error              |            |  | —         | —    | $\pm 2$    |      |

Note : Quantizing error is not contained in those errors.

## A / D CONVERSION CHARACTERISTICS (II)

 $(V_{SS} = 0V, V_{DD} = 2.2 \text{ to } 2.7V, T_{opr} = -10 \text{ to } 70^\circ\text{C})$ 

| PARAMETER                      | SYMBOL            | CONDITIONS  | Min       | Typ. | Max.       | UNIT |
|--------------------------------|-------------------|---|-----------|------|------------|------|
| Analog Reference Voltage       | $V_{AREF}$        |   | 2.2       | —    | $V_{DD}$   | V    |
|                                | $V_{ASS}$         |   | $V_{SS}$  |      |            |      |
| Analog Reference Voltage Range | $\Delta V_{AREF}$ |   | 2.2       | —    | —          | V    |
| Analog Input Voltage           | $V_{AIN}$         |   | $V_{ASS}$ | —    | $V_{AREF}$ | V    |
| Analog Supply Current          | $I_{REF}$         | $V_{AREF} = 5.5V, V_{ASS} = 0.0V$   | —         | 0.5  | 1.0        | mA   |
| Nonlinearity Error             |                   | $V_{DD} = 2.2V, V_{SS} = 0.0V$<br>$V_{AREF} = 2.200V$<br>$V_{ASS} = 0.000V$ | —         | —    | $\pm 2$    | LSB  |
| Zero Point Error               |                   |   | —         | —    | $\pm 2$    |      |
| Full Scale Error               |                   |   | —         | —    | $\pm 2$    |      |
| Total Error                    |                   |   | —         | —    | $\pm 4$    |      |

Note : Quantizing error is not contained in those errors.

**A.C. CHARACTERISTICS ( I )** ( $V_{SS} = 0V, V_{DD} = 4.5 \text{ to } 5.5V, T_{opr} = -10 \text{ to } 70^\circ\text{C}$ )

| PARAMETER                    | SYMBOL    | CONDITIONS   | Min.  | Typ. | Max.  | UNIT          |
|------------------------------|-----------|--|-------|------|-------|---------------|
| Machine Cycle Time           | $t_{cy}$  | In NORMAL 1, 2 mode  | 0.5   | —    | 10    | $\mu\text{s}$ |
|                              |           | In IDLE 1, 2 mode  |       |      |       |               |
|                              |           | In SLOW mode   | 117.6 | —    | 133.3 |               |
|                              |           | In SLEEP mode  |       |      |       |               |
| High Level Clock Pulse Width | $t_{WCH}$ | For external clock operation<br>(XIN input), $f_c = 8 \text{ MHz}$       | 62.5  | —    | —     | ns            |
| Low Level Clock Pulse Width  | $t_{WCL}$ |  |       |      |       |               |
| High Level Clock Pulse Width | $t_{WSH}$ | For external clock operation<br>(XTIN input), $f_s = 32.768 \text{ kHz}$ | 14.7  | —    | —     | $\mu\text{s}$ |
| Low Level Clock Pulse Width  | $t_{WSL}$ |  |       |      |       |               |

**A.C. CHARACTERISTICS (II)** ( $V_{SS} = 0V, V_{DD} = 2.2 \text{ to } 5.5V, T_{opr} = -10 \text{ to } 70^\circ\text{C}$ )

| PARAMETER                    | SYMBOL    | CONDITIONS   | Min.  | Typ. | Max.  | UNIT          |
|------------------------------|-----------|--|-------|------|-------|---------------|
| Machine Cycle Time           | $t_{cy}$  | In NORMAL 1, 2 mode  | 0.95  | —    | 10    | $\mu\text{s}$ |
|                              |           | In IDLE 1, 2 mode  |       |      |       |               |
|                              |           | In SLOW mode   | 117.6 | —    | 133.3 |               |
|                              |           | In SLEEP mode  |       |      |       |               |
| High Level Clock Pulse Width | $t_{WCH}$ | For external clock operation<br>(XIN input), $f_c = 4.2 \text{ MHz}$     | 110   | —    | —     | ns            |
| Low Level Clock Pulse Width  | $t_{WCL}$ |  |       |      |       |               |
| High Level Clock Pulse Width | $t_{WSH}$ | For external clock operation<br>(XTIN input), $f_s = 32.768 \text{ kHz}$ | 14.7  | —    | —     | $\mu\text{s}$ |
| Low Level Clock Pulse Width  | $t_{WSL}$ |  |       |      |       |               |

RECOMENDED OSCILLATING CONDITION ( I )

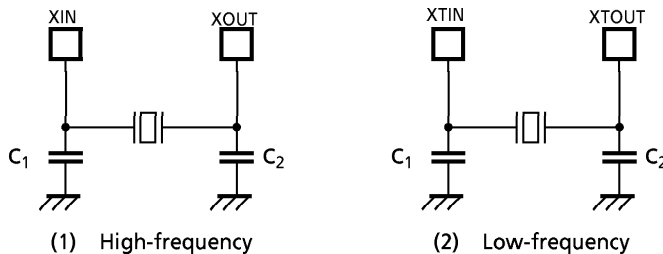
(V<sub>SS</sub> = 0V, V<sub>DD</sub> = 4.5 to 5.5V, Topr = - 10 to 70 °C)

| PARAMETER      | OSILLATOR          | FREQUENCY  | RECOMMENDER OSCILLATOR           |                          | RECOMMENDED CONDITION |                  |
|----------------|--------------------|------------|----------------------------------|--------------------------|-----------------------|------------------|
|                |                    |            |                                  |                          | C <sub>1</sub>        | C <sub>2</sub>   |
| High-frequency | Ceramic Resonator  | 8 MHz      | KYOCERA                          | KBR8.0M                  | 30pF                  | 30pF             |
|                |                    |            | Standard/Lead Type (MURATA)      | CSA8.00MTZ<br>CST8.00MTW | built-in<br>30pF      | built-in<br>30pF |
|                |                    |            | Standard/SMP Type (MURATA)       | CSAC8.00MT               | 30pF                  | 30pF             |
|                |                    |            | Standard/Small ChipType (MURATA) | CSTC8.00MT               | built-in<br>30pF      | built-in<br>30pF |
|                |                    | 4 MHz      | KYOCERA                          | KBR4.0MS                 | 30pF                  | 30pF             |
|                | Crystal Oscillator | 8 MHz      | TOYOCOM                          | 210B 8.0000              | 20pF                  | 20pF             |
|                | 4 MHz              | TOYOCOM    | 204B 4.0000                      |                          |                       |                  |
| Low-frequency  | Crystal Oscillator | 32.768 kHz | NDK                              | MX-38T                   | 15pF                  | 15pF             |

RECOMENDED OSCILLATING CONDITION ( II )

(V<sub>SS</sub> = 0V, V<sub>DD</sub> = 2.2 to 5.5V, Topr = - 10 to 70 °C)

| PARAMETER      | OSILLATOR         | FREQUENCY | RECOMMENDER OSCILLATOR      |  | RECOMMENDED CONDITION    |                          |
|----------------|-------------------|-----------|-----------------------------|--|--------------------------|--------------------------|
|                |                   |           |                             |  | C <sub>1</sub>           | C <sub>2</sub>           |
| High-frequency | Ceramic Resonator | 4 MHz     | Standard/Lead Type (MURATA) | CSA4.00MG<br>CST4.00MGW                  | 30pF<br>built-in<br>30pF | 30pF<br>built-in<br>30pF |
|                |                   |           | Standard/SMD Type (MURATA)  | CSA4.00MGC<br>CSAC4.00MGCM<br>CSTC4.00MG | 30pF                     | 30pF                     |
|                |                   |           |                             |  | built-in<br>30pF         | built-in<br>30pF         |
|                |                   |           | Standard/Small Chip Type    | CSTCS4.00MG                              | built-in<br>10pF         | built-in<br>10pF         |



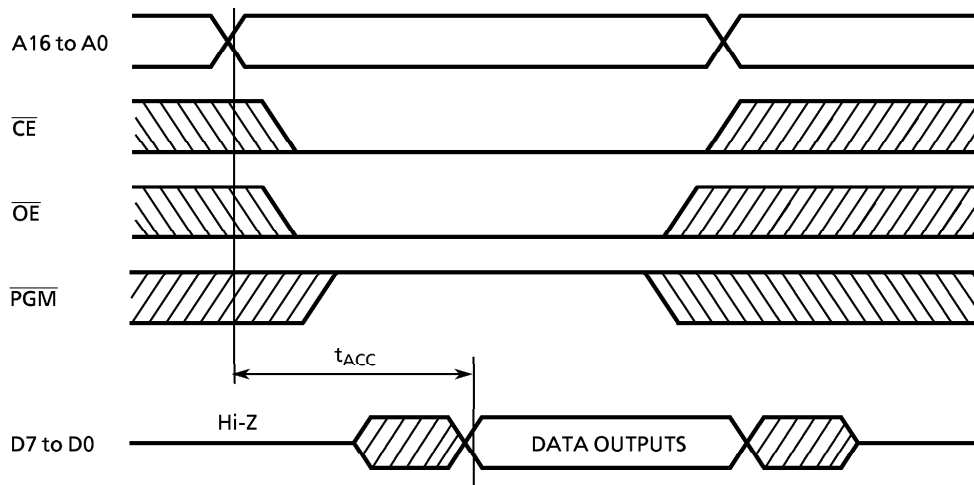
Note : When used in high electric field such as a picture tube, the package is recommended to be electrically shielded to maintain a regular operation.

D.C./A.C. CHARACTERISTICS (PROM mode) ( $V_{SS} = 0V$ )

(1) Read Operation

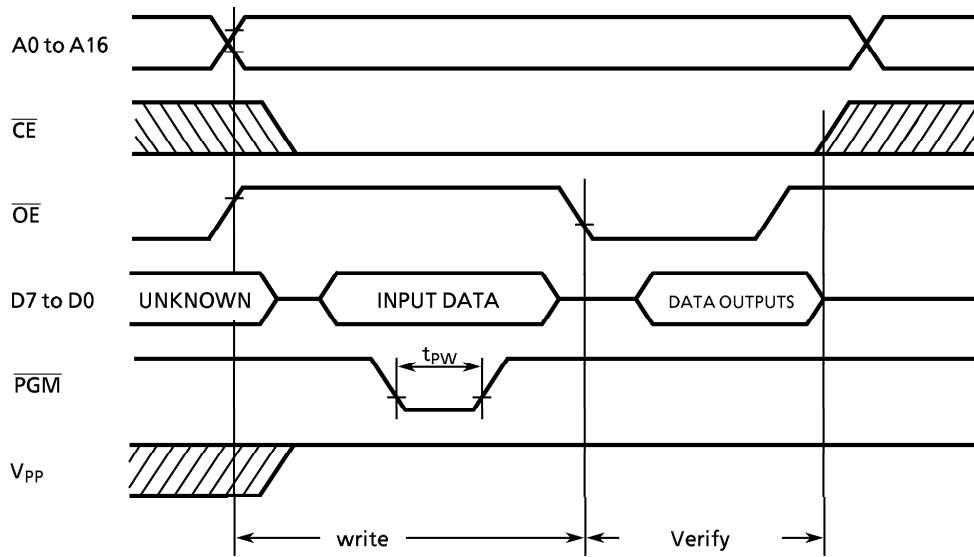
| PARAMETER                    | SYMBOL    | CONDITIONS               | Min.                | Typ.               | Max.                 | UNIT |
|------------------------------|-----------|--------------------------|---------------------|--------------------|----------------------|------|
| Input High Voltage           | $V_{IH4}$ |                          | $V_{CC} \times 0.7$ | —                  | $V_{CC}$             | V    |
| Input Low Voltage            | $V_{IL4}$ |                          | 0                   | —                  | $V_{CC} \times 0.12$ | V    |
| Power Supply Voltage         | $V_{CC}$  |                          | 4.75                | 5.0                | 5.25                 | V    |
| Program Power Supply Voltage | $V_{PP}$  |                          |                     |                    |                      | V    |
| Address Access Time          | $t_{ACC}$ | $V_{CC} = 5.0 \pm 0.25V$ | —                   | $1.5t_{cyc} + 300$ | —                    | ns   |

(Note)  $t_{cyc} = 500$  ns at 8 MHz



(2) High-Speed Programming Operation ( $T_{opr} = 25 \pm 5^\circ C$ )

| PARAMETER                    | SYMBOL    | CONDITIONS      | Min.                | Typ.  | Max.                 | UNIT |
|------------------------------|-----------|-----------------|---------------------|-------|----------------------|------|
| Input High Voltage           | $V_{IH4}$ |                 | $V_{CC} \times 0.7$ | —     | $V_{CC}$             | V    |
| Input Low Voltage            | $V_{IL4}$ |                 | 0                   | —     | $V_{CC} \times 0.12$ | V    |
| Power Supply Voltage         | $V_{CC}$  |                 | 6.0                 | 6.25  | 6.5                  | V    |
| Program Power Supply Voltage | $V_{PP}$  |                 | 12.5                | 12.75 | 13.0                 | V    |
| Initial Program Pulse Width  | $t_{PW}$  | $V_{CC} = 6.0V$ | 0.095               | 0.1   | 0.105                | ms   |



- Note 1 :** When  $V_{CC}$  power supply is turned on or after,  $V_{pp}$  must be increased.  
 When  $V_{CC}$  power supply is turned off or before,  $V_{pp}$  must be increased.
- Note 2 :** The device must not be set to the EPROM programmer or picked up from it under applying the program voltage ( $12.5V \pm 0.5v = V$ ) to the  $V_{pp}$  pin as the device is damaged.
- Note 3 :** Be sure to execute the recommended programing mode with the recommended programing adaptor. If a mode or an adaptor except the above, the misoperation sometimes occurs.