

## CMOS 8-Bit Microcontroller

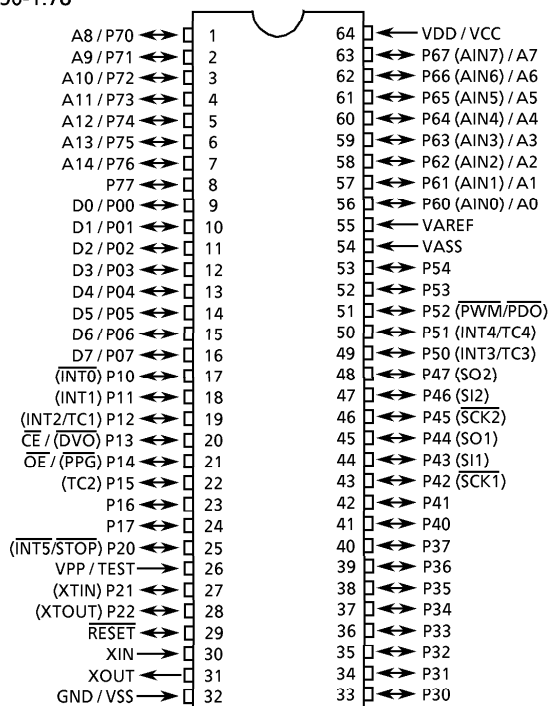
**TMP87PH40AN, TMP87PH40AF, TMP87PM40AN, TMP87PM40AF**

The 87PH40A is a One-Time PROM microcontroller with low-power 128 K bits (16 Kbytes) electrically programmable read only memory for the 87C840/CC40/CH40 system evaluation. The 87PM40A is a One-time PROM microcontroller with low-power 256 K bits (32 Kbytes) electrically programmable read only memory for the 87CK40A/M40A system evaluation. The 87PH40A/PM40A are pin compatible with the 87C840/CC40/CH40/CK40A/CM40A. The operations possible with the 87C840/CC40/CH40/CK40A/CM40A can be performed by writing programs to PROM. The 87PH40A/PM40A can write and verify in the same way as the TC57256AD using an adaptor socket BM1136/BM1137 and an EPROM programmer.

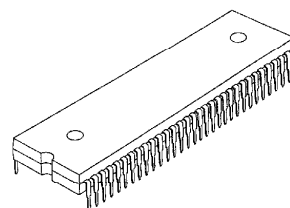
| Part No     | OTP          | RAM         | Package            | Adapter socket |
|-------------|--------------|-------------|--------------------|----------------|
| TMP87PH40AN | 16 K × 8-bit | 512 × 8-bit | P-SDIP64-750-1.78  | BM1136         |
| TMP87PH40AF |              |             | P-QFP64-1420-1.00A | BM1137         |
| TMP87PM40AN | 32 K × 8-bit | 1K × 8-bit  | P-SDIP64-750-1.78  | BM1136         |
| TMP87PM40AF |              |             | P-QFP64-1420-1.00A | BM1137         |

**Pin Assignments (Top View) - (1)**

P-SDIP64-750-1.78



P-SDIP64-750-1.78

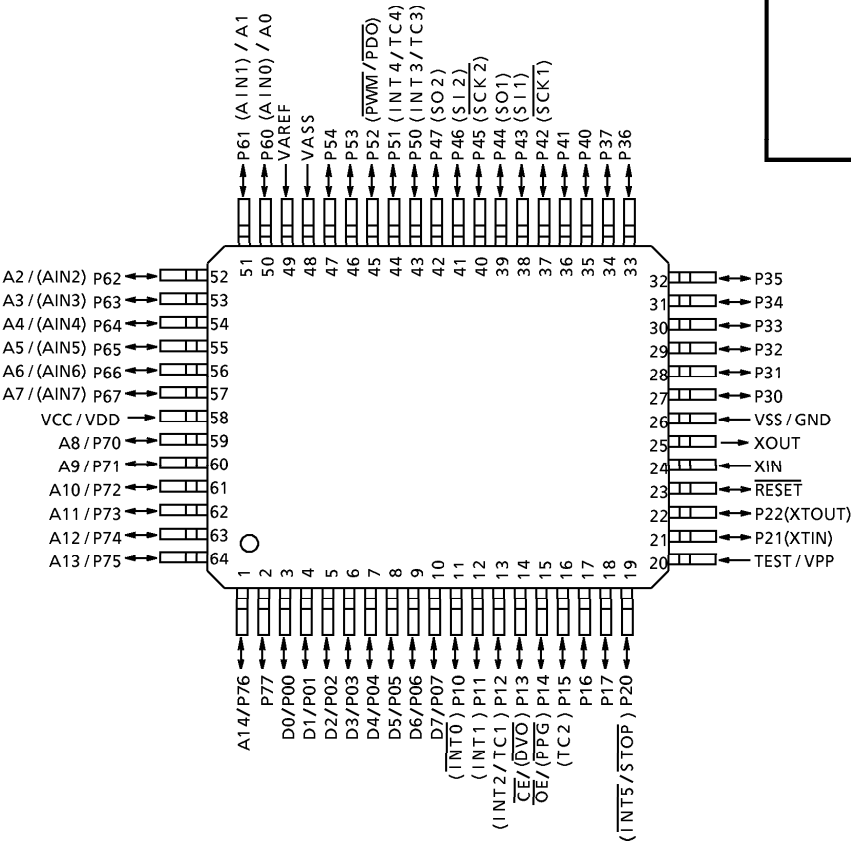
TMP87PH40AN  
TMP87PM40AN

980910EBP1

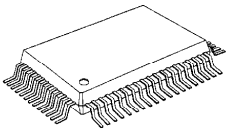
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Pin Assignments (Top View) - (2)

P-QFP64-1420-1.00A



P-QFP64-1420-1.00A



TMP87PH40AF  
TMP87PM40AF

## Pin Function

The 87PH40A/PM40A have two modes: MCU and PROM.

### (1) MCU mode

In this mode, the 87PH40A/PM40A are pin compatible with the 87C840/CC40/CH40/CK40A/CM40A (fix the TEST pin at low level).

### (2) PROM mode

| Pin Name<br>(PROM mode) | Input/Output | Functions                                                   | Pin Name<br>(MCU mode)                          |
|-------------------------|--------------|-------------------------------------------------------------|-------------------------------------------------|
| A14 to A8               | Input        | PROM address inputs                                         | P76 to P70                                      |
| A7 to A0                |              |                                                             | P67 to P60                                      |
| 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                                             |
| VPP                     | Power supply | + 12.5V / 5V (Program supply voltage)                       | TEST                                            |
| VCC                     |              | + 5V                                                        | VDD                                             |
| GND                     |              | 0V                                                          | VSS                                             |
| P37 to P30              | I/O          | Pull-up with resistance for input processing                | PROM mode setting pins. Be fixed at high level. |
| P47 to P40              |              |                                                             |                                                 |
| P54 to P50              |              |                                                             |                                                 |
| P11                     |              | PROM mode setting pins. Be fixed at high level.             |                                                 |
| P21                     |              |                                                             |                                                 |
| P77                     |              |                                                             |                                                 |
| P17 to P15              |              | PROM mode setting pins. Be fixed at low level.              |                                                 |
| P12, P10                |              |                                                             |                                                 |
| P22, P20                |              |                                                             |                                                 |
| RESET                   |              |                                                             |                                                 |
| XIN                     | Input        | Connect an 8MHz oscillator to stabilize the internal state. |                                                 |
| XOUT                    | Output       |                                                             |                                                 |
| VAREF                   | Power Supply | 0 V (GND)                                                   |                                                 |
| VASS                    |              |                                                             |                                                 |

**Operational Description**

The following explains the 87PH40A/PM40A hardware configuration and operation. The configuration and functions of the 87PH40A are the same as those of the 87C840/CC40/CH40, 87PM40A are the same as those of the 87CK40A/CM40A, except in that a one-time PROM is used instead of an on-chip mask ROM.

The 87PH40A/PM40A are 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 87PH40A/PM40A have 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 87C840/CC40/CH40/CK40A/CM40A (the TEST / VPP pin cannot be used open because it has no built-in pull-down resistance).

**1.1.1 Program Memory**

The 87PH40A has a 16 K × 8-bit (addresses C000<sub>H</sub> to FFFF<sub>H</sub> in the MCU mode, addresses 4000<sub>H</sub> to 7FFF<sub>H</sub> in the PROM mode), the 87PM40A has a 32 K × 8-bit (address 8000<sub>H</sub> to FFFF<sub>H</sub> in the MCU mode, address 0000<sub>H</sub> to 7FFF<sub>H</sub> in the PROM mode) of program memory (OTP).

To use the 87PH40A/PM40A as the system evaluation for the 87C840/CC40/CH40/CK40A/CM40A, the program should be written to the program memory area as shown in Figure 1-1.

## Electrical Characteristics

## Absolute Maximum Ratings

(V<sub>SS</sub> = 0V)

| Parameter                                   | Symbol              | Conditions                                           | Ratings                        | Unit |
|---------------------------------------------|---------------------|------------------------------------------------------|--------------------------------|------|
| Supply Voltage                              | V <sub>DD</sub>     |                                                      | – 0.3 to 7                     | V    |
| Program Voltage                             | V <sub>PP</sub>     | TEST / V <sub>PP</sub> pin                           | – 0.3 to 13.0                  | V    |
| Input Voltage                               | V <sub>IN</sub>     |                                                      | – 0.3 to V <sub>DD</sub> + 0.3 | V    |
| Output Voltage                              | V <sub>OUT1</sub>   | Except sink open drain pin, but include P2 and RESET | – 0.3 to V <sub>DD</sub> + 0.3 | V    |
|                                             | V <sub>OUT2</sub>   | Sink open drain pin except port P2, RESET            | – 0.3 to 10                    |      |
| Output Current (Per 1 pin)                  | I <sub>OUT1</sub>   | Ports P0, P1, P2, P4, P5, P6, P7                     | 3.2                            | mA   |
|                                             | I <sub>OUT2</sub>   | Port P3                                              | 30                             |      |
| Output Current (Total)                      | Σ I <sub>OUT1</sub> | Ports P0, P1, P2, P4, P5, P6, P7                     | 120                            | mA   |
|                                             | Σ I <sub>OUT2</sub> | Port P3                                              | 120                            |      |
| Power Dissipation [T <sub>opr</sub> = 70°C] | PD                  | TMP87PH40AN/PM40AN                                   | 600                            | mW   |
|                                             |                     | TMP87PH40AF/PM40AF                                   | 350                            |      |
| Soldering Temperature (time)                | T <sub>sld</sub>    |                                                      | 260 (10s)                      | °C   |
| Storage Temperature                         | T <sub>stg</sub>    |                                                      | – 55 to 125                    | °C   |
| Operating Temperature                       | T <sub>opr</sub>    |                                                      | – 30 to 70                     | °C   |

**Note:** The absolute maximum ratings are rated values which must not be exceeded during operation, even for an instant. Any one of the ratings must not be exceeded. If any absolute maximum rating is exceeded, a device may break down or its performance may be degraded, causing it to catch fire or explode resulting in injury to the user. Thus, when designing products which include this device, ensure that no absolute maximum rating value will ever be exceeded.

## Recommended Operating Conditions

(V<sub>SS</sub> = 0V, T<sub>opr</sub> = – 30 to 70°C)

| Parameter          | Symbol           | Pins                    | Conditions                   |                        | Min                    | Max                    | Unit |
|--------------------|------------------|-------------------------|------------------------------|------------------------|------------------------|------------------------|------|
| Supply Voltage     | V <sub>DD</sub>  |                         | fc = 8 MHz                   | NORMAL1, 2 mode        | 4.5                    | 6.0                    | V    |
|                    |                  |                         |                              | IDLE1, 2 mode          |                        |                        |      |
|                    |                  |                         | fc = 4.2 MHz                 | NORMAL1, 2 mode        | 2.7                    |                        |      |
|                    |                  |                         |                              | IDLE1, 2 mode          |                        |                        |      |
|                    |                  |                         | fs = 32.768 kHz              | SLOW mode              |                        |                        |      |
|                    |                  |                         |                              | SLEEP mode             |                        |                        |      |
|                    | STOP mode        | 2.0                     |                              |                        |                        |                        |      |
| Input High Voltage | V <sub>IH1</sub> | Except hysteresis input | V <sub>DD</sub> ≥ 4.5 V      |                        | 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> < 4.5 V      | V <sub>DD</sub> × 0.90 |                        |                        |      |
| Input Low Voltage  | V <sub>IL1</sub> | Except hysteresis input | V <sub>DD</sub> ≥ 4.5 V      |                        | 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> < 4.5 V      | V <sub>DD</sub> × 0.10 |                        |                        |      |
| Clock Frequency    | fc               | XIN, XOUT               | V <sub>DD</sub> = 4.5 to 6 V |                        | 0.4                    | 8.0                    | MHz  |
|                    |                  |                         | V <sub>DD</sub> = 2.7 to 6 V |                        |                        | 4.2                    |      |
|                    | fs               | XTIN, XTOUT             |                              |                        | 30.0                   | 34.0                   | kHz  |

**Note 1:** The recommended operating conditions for a device are operating conditions under which it can be guaranteed that the device will operate as specified. If the device is used under operating conditions other than the recommended operating conditions (supply voltage, operating temperature range, specified AC/DC values etc.), malfunction may occur. Thus, when designing products which include this device, ensure that the recommended operating conditions for the device are always adhered to.

**Note 2:** Clock frequency fc; Supply voltage range is specified in NORMAL mode and IDLE mode.

## D.C. Characteristics

(V<sub>SS</sub> = 0 V, T<sub>opr</sub> = – 30 to 70°C)

| Parameter                          | Symbol           | Pins                                 | Conditions                                            | Min | Typ. | Max | Unit |
|------------------------------------|------------------|--------------------------------------|-------------------------------------------------------|-----|------|-----|------|
| Hysteresis Voltage                 | V <sub>HS</sub>  | Hysteresis inputs                    | V <sub>DD</sub> = 5.0V                                | –   | 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>DD</sub> = 5.5V, V <sub>OUT</sub> = 5.5V/0V    | –   | –    | ± 2 |      |
| Output High Voltage                | V <sub>OH2</sub> | Tri-state ports                      | V <sub>DD</sub> = 4.5V, I <sub>OH</sub> = – 0.7mA     | 4.1 | –    | –   | V    |
| Output Low Voltage                 | V <sub>OL</sub>  | Except XOUT and port P3              | V <sub>DD</sub> = 4.5V, I <sub>OL</sub> = 1.6mA       | –   | –    | 0.4 | V    |
| Output Low Current                 | I <sub>OL3</sub> | Port P3                              | 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      | –   | 9    | 14  | mA   |
| Supply Current in IDLE 1, 2 mode   |                  |                                      | f <sub>s</sub> = 32.768 kHz                           | –   | 12   | 18  |      |
| Supply Current in SLOW mode        |                  |                                      | V <sub>IN</sub> = 5.3V/0.2V                           | –   | 4    | 6   | mA   |
| Supply Current in SLEEP mode       |                  |                                      | V <sub>DD</sub> = 3.0V<br>f <sub>s</sub> = 32.768 kHz | –   | 4.5  | 6   |      |
| Supply Current in STOP mode        |                  |                                      | V <sub>IN</sub> = 2.8V/0.2V                           | –   | 30   | 60  | μA   |
| Supply Current in STOP mode        |                  |                                      | V <sub>DD</sub> = 5.5V<br>V <sub>IN</sub> = 5.3V/0.2V | –   | 15   | 30  | μA   |
| Supply Current in STOP mode        |                  |                                      |                                                       | –   | 0.5  | 10  | μA   |

Note1: Typical values show those at T<sub>opr</sub> = 25°C.Note 2: Input Current I<sub>IN1</sub>, I<sub>IN3</sub>; The current through pull-up or pull-down resistor is not included.Note 3: I<sub>DD</sub>; Except for I<sub>REF</sub>

## A / D Conversion Characteristics

(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 2.7 to 5.5 V, T<sub>opr</sub> = – 30 to 70°C)

| Parameter                | Symbol            | Conditions                                                                      | Min              | Typ. | Max               | Unit |
|--------------------------|-------------------|---------------------------------------------------------------------------------|------------------|------|-------------------|------|
| Analog Reference Voltage | V <sub>AREF</sub> | V <sub>AREF</sub> – V <sub>ASS</sub> ≥ 2.5 V                                    | 2.7              | –    | V <sub>DD</sub>   | V    |
|                          | V <sub>ASS</sub>  |                                                                                 | V <sub>SS</sub>  | –    | 1.5               |      |
| Analog Input Voltage     | V <sub>AIN</sub>  |                                                                                 | V <sub>ASS</sub> | –    | V <sub>AREF</sub> | V    |
| Analog Supply Current    | I <sub>REF</sub>  | V <sub>AREF</sub> = 5.5 V, V <sub>ASS</sub> = 0.0 V                             | –                | 0.5  | 1.0               | mA   |
| Nonlinearity Error       |                   | V <sub>DD</sub> = 5.0 V, V <sub>SS</sub> = 0.0 V<br>V <sub>AREF</sub> = 5.000 V | –                | –    | ± 1               | LSB  |
| Zero Point Error         |                   | V <sub>ASS</sub> = 0.000 V<br>or                                                | –                | –    | ± 1               |      |
| Full Scale Error         |                   | V <sub>DD</sub> = 2.7 V, V <sub>SS</sub> = 0.0 V<br>V <sub>AREF</sub> = 2.700 V | –                | –    | ± 1               |      |
| Total Error              |                   | V <sub>ASS</sub> = 0.000 V                                                      | –                | –    | ± 2               |      |

Note : The above errors has no quantizing error.

A.C. Characteristics

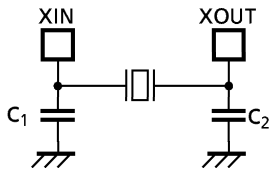
(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 4.5 to 6.0 V, Topr = – 30 to 70°C)

| Parameter                    | Symbol           | Conditions                                                             | Min   | Typ. | Max   | Unit |
|------------------------------|------------------|------------------------------------------------------------------------|-------|------|-------|------|
| Machine Cycle Time           | t <sub>cy</sub>  | In NORMAL1, 2 modes                                                    | 0.5   | –    | 10    | μs   |
|                              |                  | In IDLE1, 2 modes                                                      |       |      |       |      |
|                              |                  | In SLOW mode                                                           | 117.6 | –    | 133.3 |      |
|                              |                  | In SLEEP mode                                                          |       |      |       |      |
| High Level Clock Pulse Width | t <sub>WCH</sub> | For external clock operation (XIN input), f <sub>c</sub> = 8 MHz       | 50    | –    | –     | ns   |
| Low Level Clock Pulse Width  | t <sub>WCL</sub> |                                                                        |       |      |       |      |
| High Level Clock Pulse Width | t <sub>WSH</sub> | For external clock operation (XTIN input), f <sub>s</sub> = 32.768 kHz | 14.7  | –    | –     | μs   |
| Low Level Clock Pulse Width  | t <sub>WSL</sub> |                                                                        |       |      |       |      |

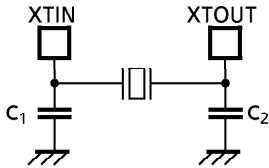
Recommended Oscillating Conditions

(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 4.5 to 6.0 V, Topr = – 30 to 70°C)

| Parameter                  | Oscillator         | Oscillation Frequency | Recommended Oscillator | Recommended Constant |                |
|----------------------------|--------------------|-----------------------|------------------------|----------------------|----------------|
|                            |                    |                       |                        | C <sub>1</sub>       | C <sub>2</sub> |
| High-frequency Oscillation | Ceramic Resonator  | 8 MHz                 | KYOCERA KBR8.0M        | 30pF                 | 30pF           |
|                            |                    |                       |                        |                      |                |
|                            |                    | 4 MHz                 | KYOCERA KBR4.0MS       |                      |                |
|                            |                    |                       | MURATA CSA4.00MG       |                      |                |
|                            | Crystal Oscillator | 8 MHz                 | TOYOCOM 210B 8.0000    | 20pF                 | 20pF           |
|                            |                    | 4 MHz                 | TOYOCOM 204B 4.0000    |                      |                |
| Low-frequency Oscillation  | Crystal Oscillator | 32.768 kHz            | NDK MX-38T             | 15pF                 | 15pF           |



(1) High-frequency Oscillation

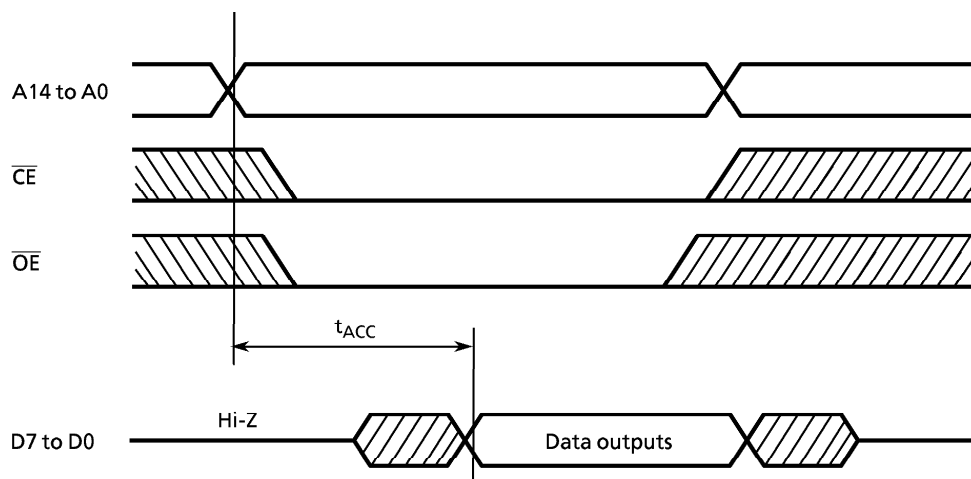


(2) Low-frequency Oscillation

**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 ( $T_{opr} = -30$  to  $70^{\circ}C$ )

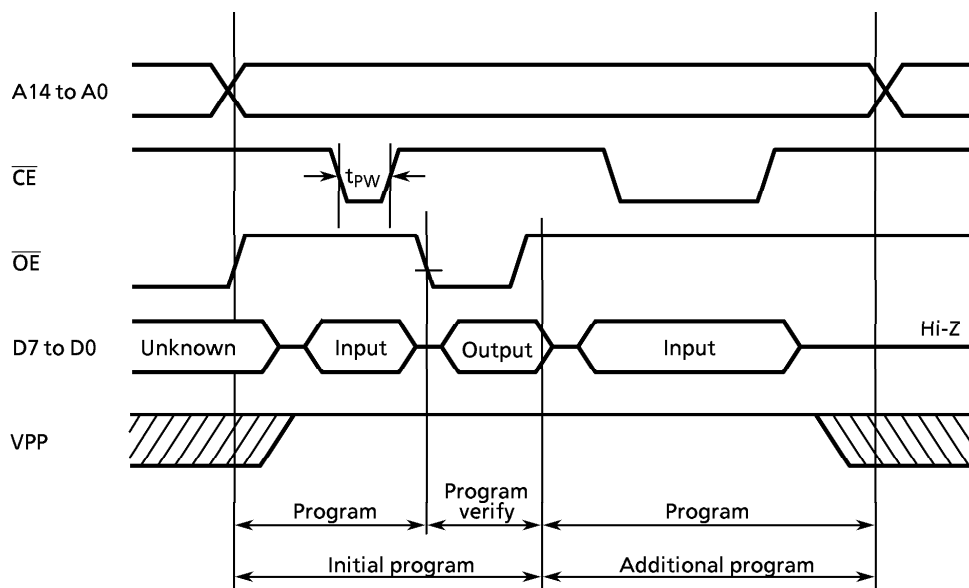
| Parameter                    | Symbol    | Conditions               | Min                 | Typ.               | Max                  | Unit |
|------------------------------|-----------|--------------------------|---------------------|--------------------|----------------------|------|
| Input High 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         | $V_{CC}$  |                          | 4.75                | 5.00               | 5.25                 | V    |
| Program Power Supply Voltage | $V_{PP}$  |                          | $V_{CC} - 0.6$      | $V_{CC}$           | $V_{CC} + 0.6$       |      |
| 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

Timing Waveforms of Read Operation

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

| 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         | $V_{CC}$  |                                                             | 5.75                | 6.0  | 6.25                 | V    |
| Program Power Supply Voltage | $V_{PP}$  |                                                             | 12.0                | 12.5 | 13.0                 | V    |
| Initial Program Pulse Width  | $t_{PW}$  | $V_{CC} = 6.0 V \pm 0.25 V$ ,<br>$V_{PP} = 12.5 \pm 0.25 V$ | 0.95                | 1.0  | 1.05                 | ms   |



Timing Waveforms of Programming Operation

**Note 1:** When  $V_{cc}$  power supply is turned on or after,  $V_{pp}$  must be increased.

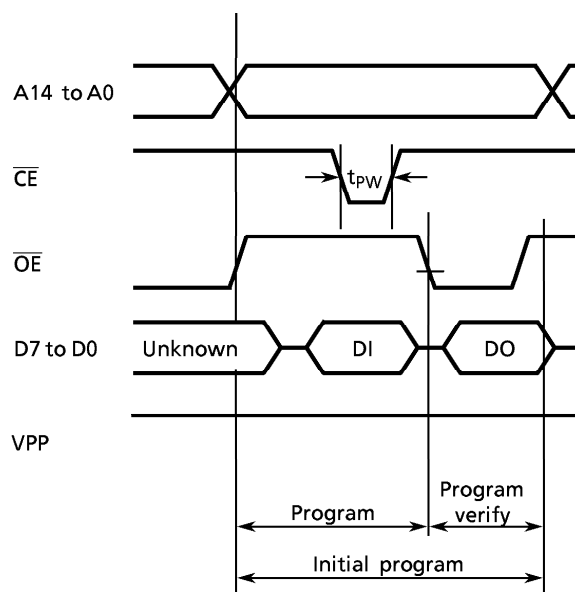
When  $V_{cc}$  power supply is turned off or before,  $V_{pp}$  must be decreased.

**Note 2:** The device must not be set to the EPROM programmer or picked up from it under applying the program voltage ( $12.5\text{ V} \pm 0.5\text{ V}$ ) to the  $V_{pp}$  pin as the device is damaged.

**Note 3:** Be sure to execute the recommended programming mode with the recommended programming adaptor. If a mode or an adaptor except the above, the misoperation sometimes occurs.

(3) Program Operation (High speed write mode - II) ( $T_{opr} = 25 \pm 5^{\circ}\text{C}$ )

| 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    |
| Supply Voltage              | $V_{CC}$  |                                                                                                 | 6.00                | 6.25  | 6.50                 | V    |
| Program Supply Voltage      | $V_{PP}$  |                                                                                                 | 12.50               | 12.75 | 13.0                 | V    |
| Initial Program Pulse Width | $t_{PW}$  | $V_{CC} = 6.25 \text{ V} \pm 0.25 \text{ V}$ ,<br>$V_{PP} = 12.75 \text{ V} \pm 0.25 \text{ V}$ | 0.095               | 0.1   | 0.105                | ms   |



Note: DO ; Data output (I0 to I7)  
DI ; Data input (I0 to I7)

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 decreased.

Note 2: The device must not be set to the EPROM programmer or picked up from it under applying the program voltage ( $12.75 \text{ V} \pm 0.25 \text{ V}$ ) to the  $V_{PP}$  pin as the device is damaged.

Note 3: Be sure to execute the recommended programming mode with the recommended programming adaptor. If a mode or an adaptor except the above, the misoperation sometimes occurs.