

## CMOS 8-Bit Microcontroller

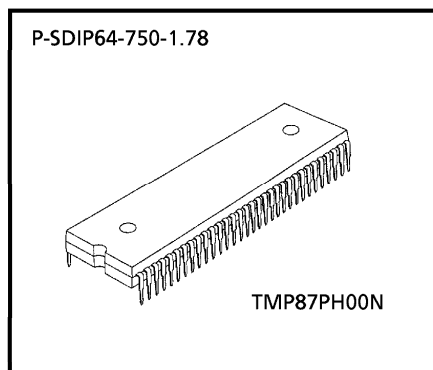
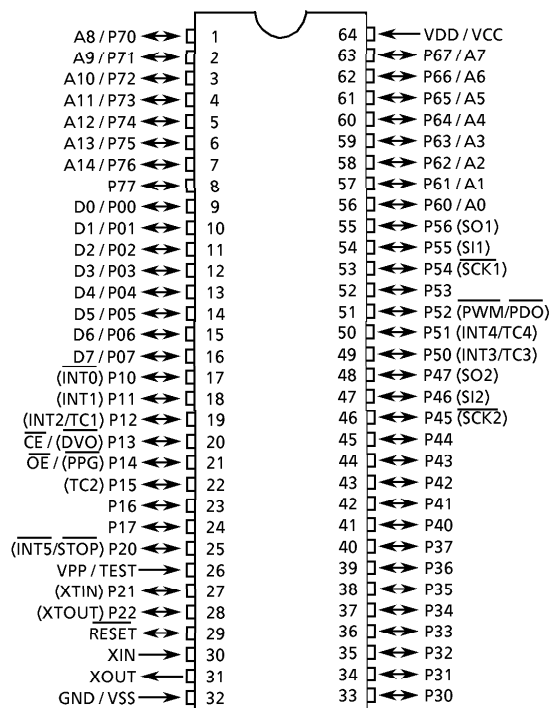
**TMP87PH00N**  
**TMP87PH00F**  
**TMP87PH00DF**  
**TMP87PH00LF**

The 87PH00 is a One-Time PROM microcontroller with low-power 128 K bits (16 Kbytes) electrically programmable read only memory for the 87C800/CH00 system evaluation. The 87PH00 is pin compatible with the 87C800/CH00. The operations possible with the 87C800/CH00 can be performed by writing programs to PROM. The 87PH00 can write and verify in the same way as the TMM27256AD using an adaptor socket BM1136/BM1137/BM1173 and an EPROM programmer.

| Part No.    | OTP          | RAM         | Package            | Adapter Socket |
|-------------|--------------|-------------|--------------------|----------------|
| TMP87PH00N  | 16 K × 8-bit | 256 × 8-bit | P-SDIP64-750-1.78  | BM1136         |
| TMP87PH00F  |              |             | P-QFP64-1420-1.00A | BM1137         |
| TMP87PH00DF |              |             | P-QFP64-1414-0.80A | BM1173         |
| TMP87PH00LF |              |             |                    |                |

## Pin Assignments (Top View)

P-SDIP64-750-1.78

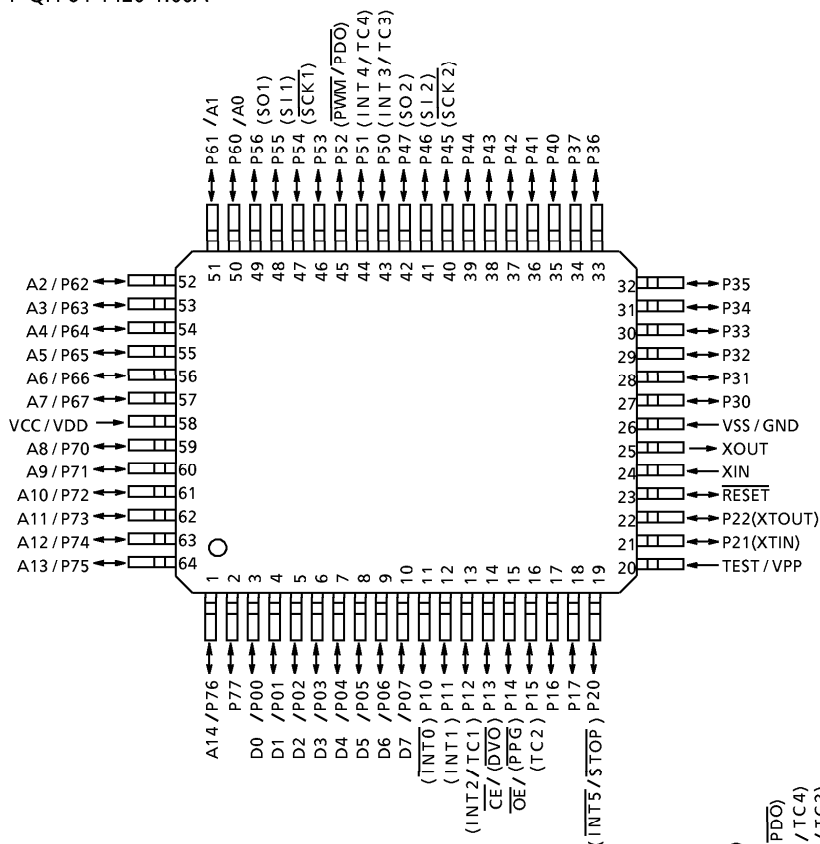


980910EBP2

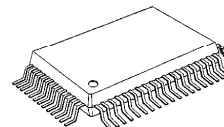
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## Pin Assignments (Top View)

P-QFP64-1420-1.00A

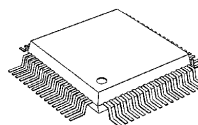


P-QFP64-1420-1.00A

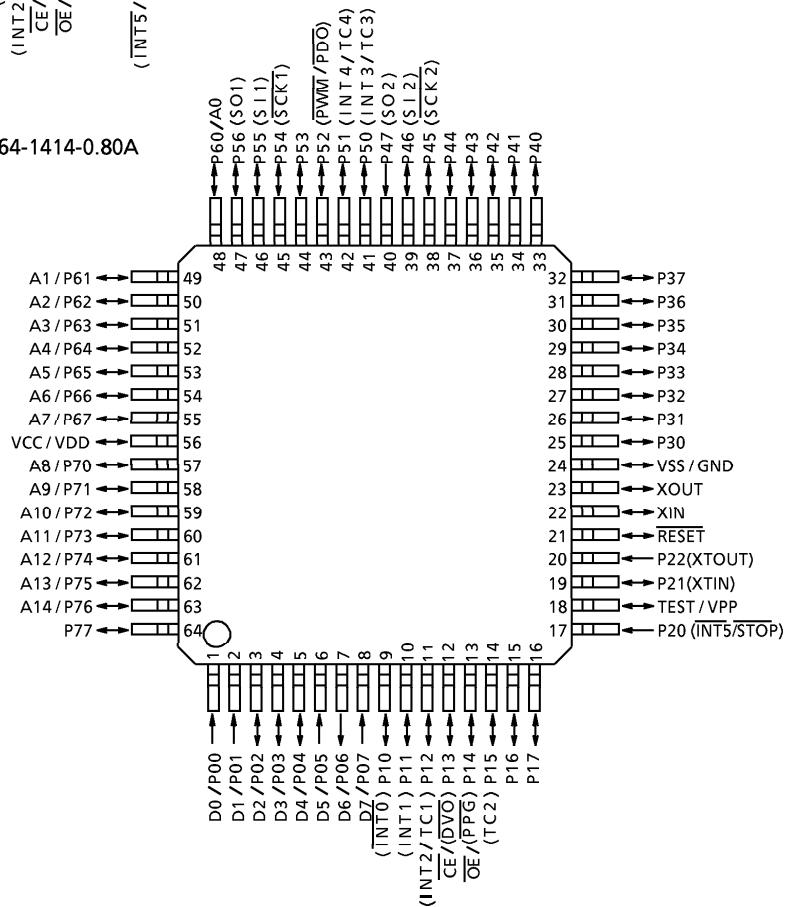


TMP87PH00F

P-QFP64-1414-0.80A

TMP87PH00DF  
TMP87PH00LF

P-QFP64-1414-0.80A



## Pin Function

The 87PH00 has two modes: MCU and PROM.

(1) MCU mode

In this mode, the 87PH00 is pin compatible with the 87C800/CH00 (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                                     |
| $\overline{\text{CE}}$    | Input        | Chip enable signal input (active low)                       | P13  |
| $\overline{\text{OE}}$    |              | Output enable signal input (active low)                     | P14  |
| VPP                       | Power supply | + 12.5 V / 5 V (Program supply voltage)                     | TEST   |
| VCC                       |              | + 5 V   | VDD  |
| GND                       |              | 0 V   | VSS  |
| P37 to P30                | I/O          | Pull-up with resistance for input processing                | PROM mode setting pin. Be fixed at high level. |
| P47 to P40                |              |   |  |
| P56 to P50                |              |   |  |
| P11                       |              | PROM mode setting pin. Be fixed at low level.               |  |
| P21                       |              |   |  |
| P77                       |              |   |  |
| P17 to P15                |              | PROM mode setting pin. Be fixed at low level.               |  |
| P12, P10                  |              |   |  |
| P22, P20                  |              |   |  |
| $\overline{\text{RESET}}$ |              |   |  |
| XIN                       | Input        | Connect an 8MHz oscillator to stabilize the internal state. |  |
| XOUT                      | Output       |   |  |

## Operational Description

The following explains the 87PH00 hardware configuration and operation. The configuration and functions of the 87PH00 are the same as those of the 87C800/CH00, except in that a one-time PROM is used instead of an on-chip mask ROM.

The 87PH00 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 87PH00 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 87C800/CH00 (the TEST / VPP pin cannot be used open because it has no built-in pull-down resistance).

##### 1.1.1 Program Memory

The 87PH00 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) of program memory (OTP).

To use the 87PH00/PH00L as the system evaluation for the 87C800/CH00/CH00L, the program should be written to the program memory area as shown in Figure 1-1.

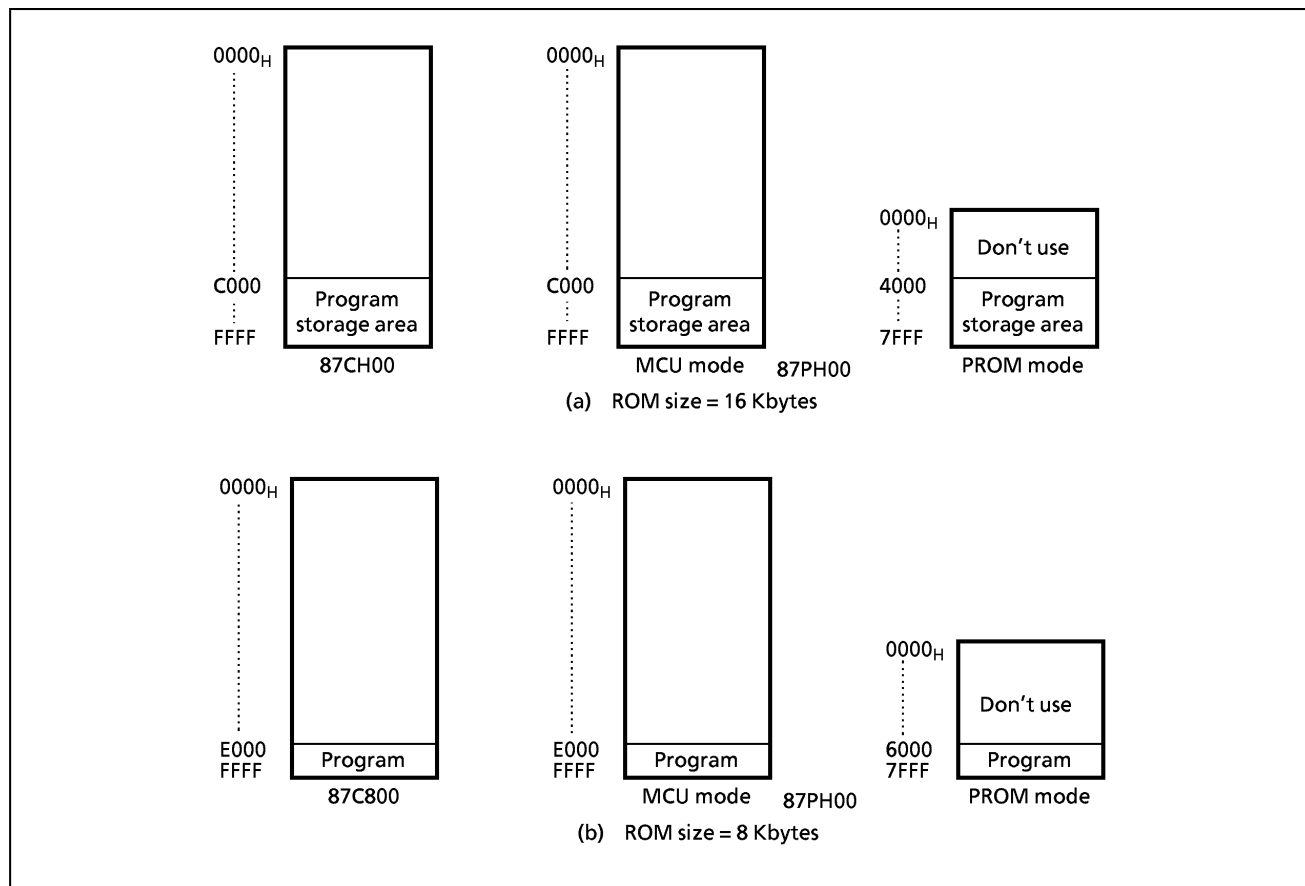


Figure 1-1. Program Memory Area

**Note:** Either write the data FFH to the unused area or set the PROM programmer to access only the program storage area.

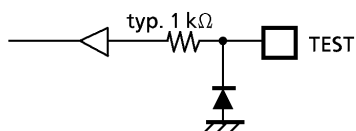
### 1.1.2 Data Memory

The 87PH00 has an on-chip  $256 \times 8$ -bit data memory (static RAM).

### 1.1.3 Input/Output Circuitry

#### (1) Control pins

The control pins of the 87PH00 are the same as those of the 87C800/CH00 except that the TEST pin has no built-in pull-down resistance.



*Note: The 87PH00 does not have a pull-down resistor for TEST pin*

Figure 1-2. TEST Pin

#### (2) I/O ports

The I/O circuitries of 87PH00 I/O ports are the same as the code A type I/O circuitries of the 87C800/CH00.

When using as an evaluator of other I/O codes (C, D, G), external pull-up resistors are required.

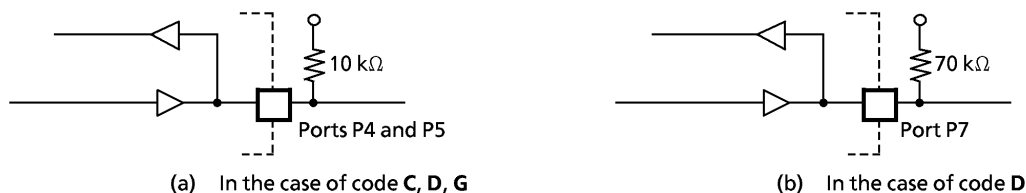


Figure 1-3. I/O Circuitry Code and External Circuitry

## 1.2 PROM Mode

The PROM mode is activated by setting the TEST,  $\overline{\text{RESET}}$  pin and the ports P17 to P10, P22 to P20 and P77 as shown in Figure 1-4. The PROM mode is used to write and verify programs with a general-purpose PROM programmer. The high-speed programming mode can be used for program operation.

The 87PH00 is not supported an *electric signature* mode, so the ROM type must be set to TC57256 AD. Set the adaptor socket switch to "P".

*Note: Please set the high-speed programming mode according to each manual of PROM programmer.*

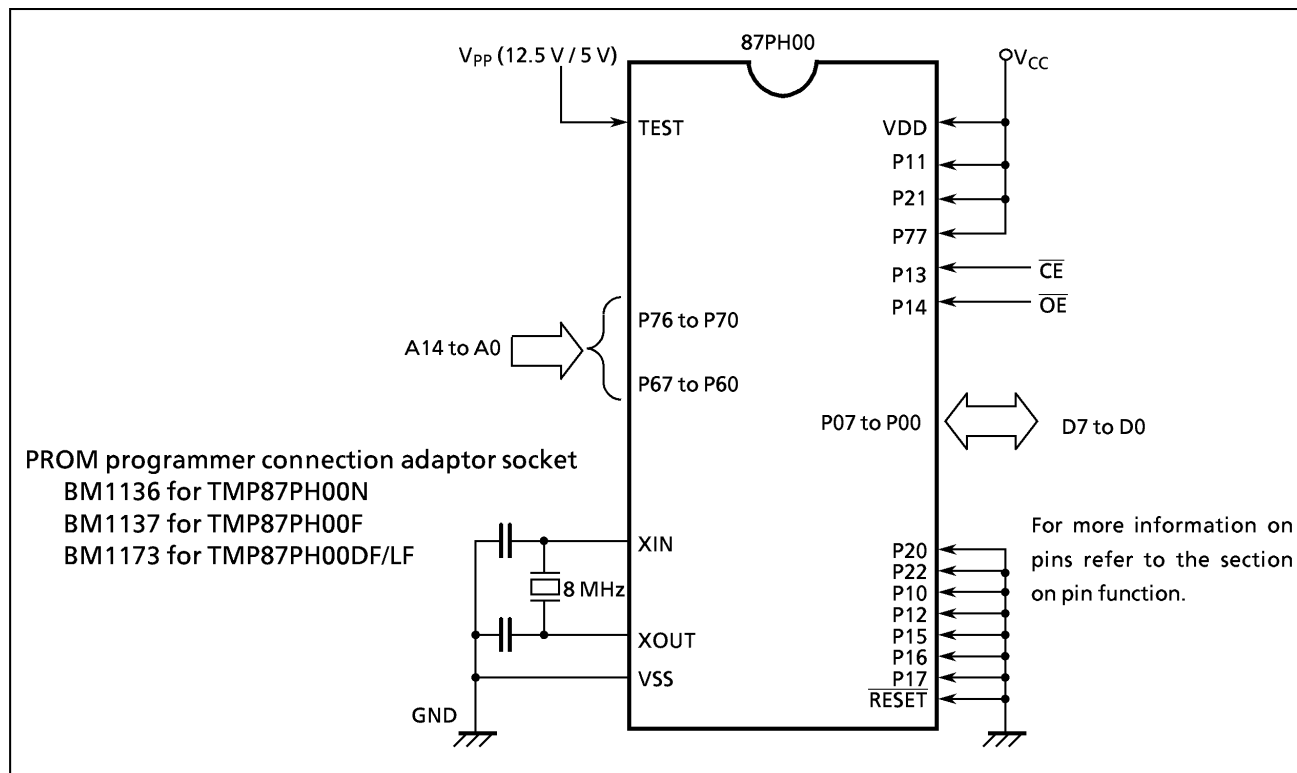


Figure 1-4. Setting for PROM Mode

### 1.2.1 Programming Flowchart (High-speed Programming Mode-I)

The high-speed programming mode is achieved by applying the program voltage (+ 12.5 V) to the Vpp pin when Vcc = 6 V. After the address and input data are stable, the data is programmed by applying a single 1ms program pulse to the  $\overline{CE}$  input. The programmed data is verified. If incorrect, another 1ms program pulse is applied and then the programmed data is verified. This process should be repeated (up to 25 times) until the program operates correctly. Programming for one address is ended by applying additional program pulse with width 3 times that needed for initial programming (number of programmed times  $\times$  1 ms). 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.

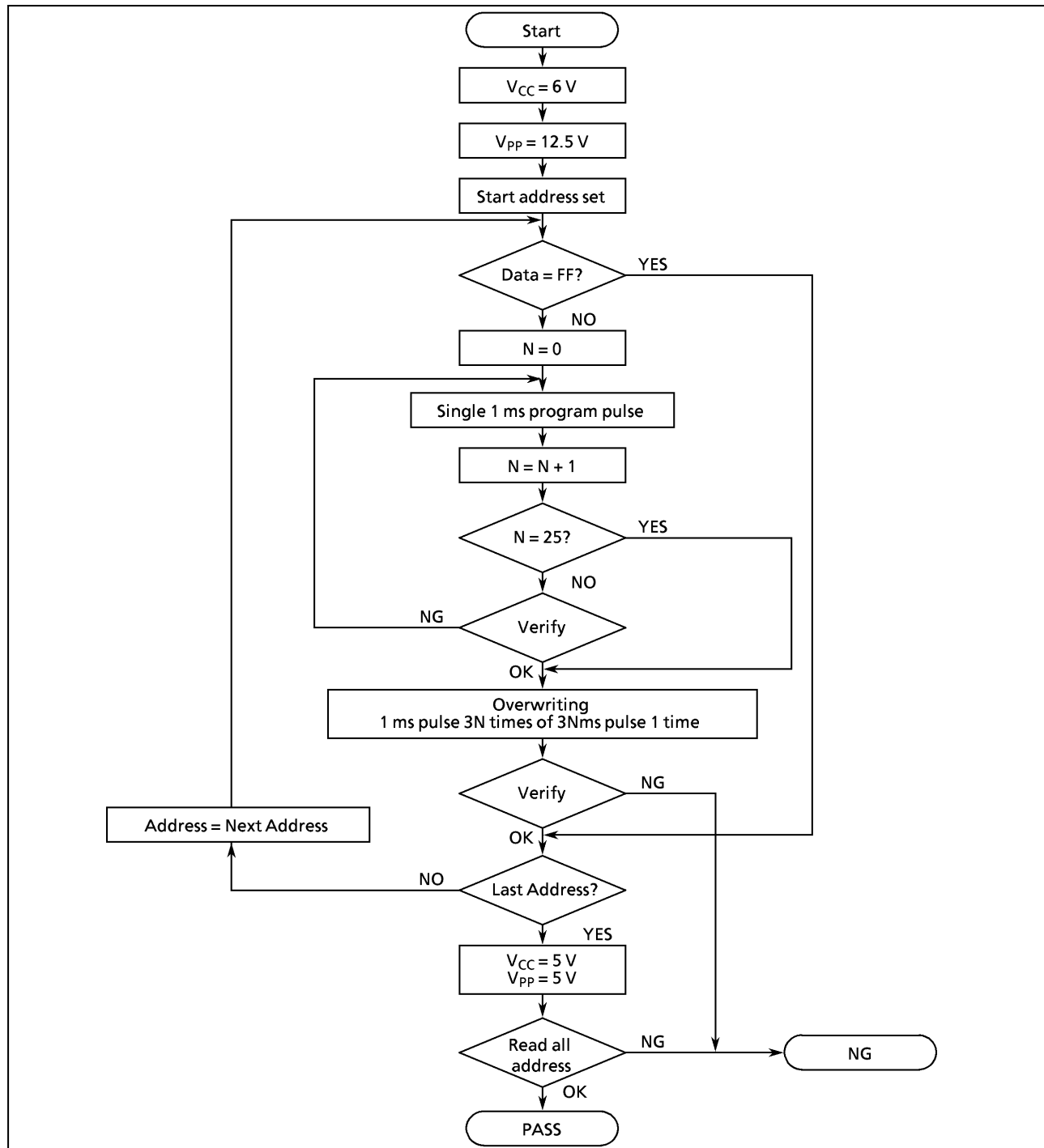


Figure 1-5. Flowchart of High-speed Programming Mode - I

### 1.2.2 Programming Flowchart (High-speed Programming Mode-II)

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 0.1ms program pulse to the  $\overline{CE}$  input. The programmed data is verified. If incorrect, another 0.1ms program pulse is applied and then the programmed data is verified. 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.

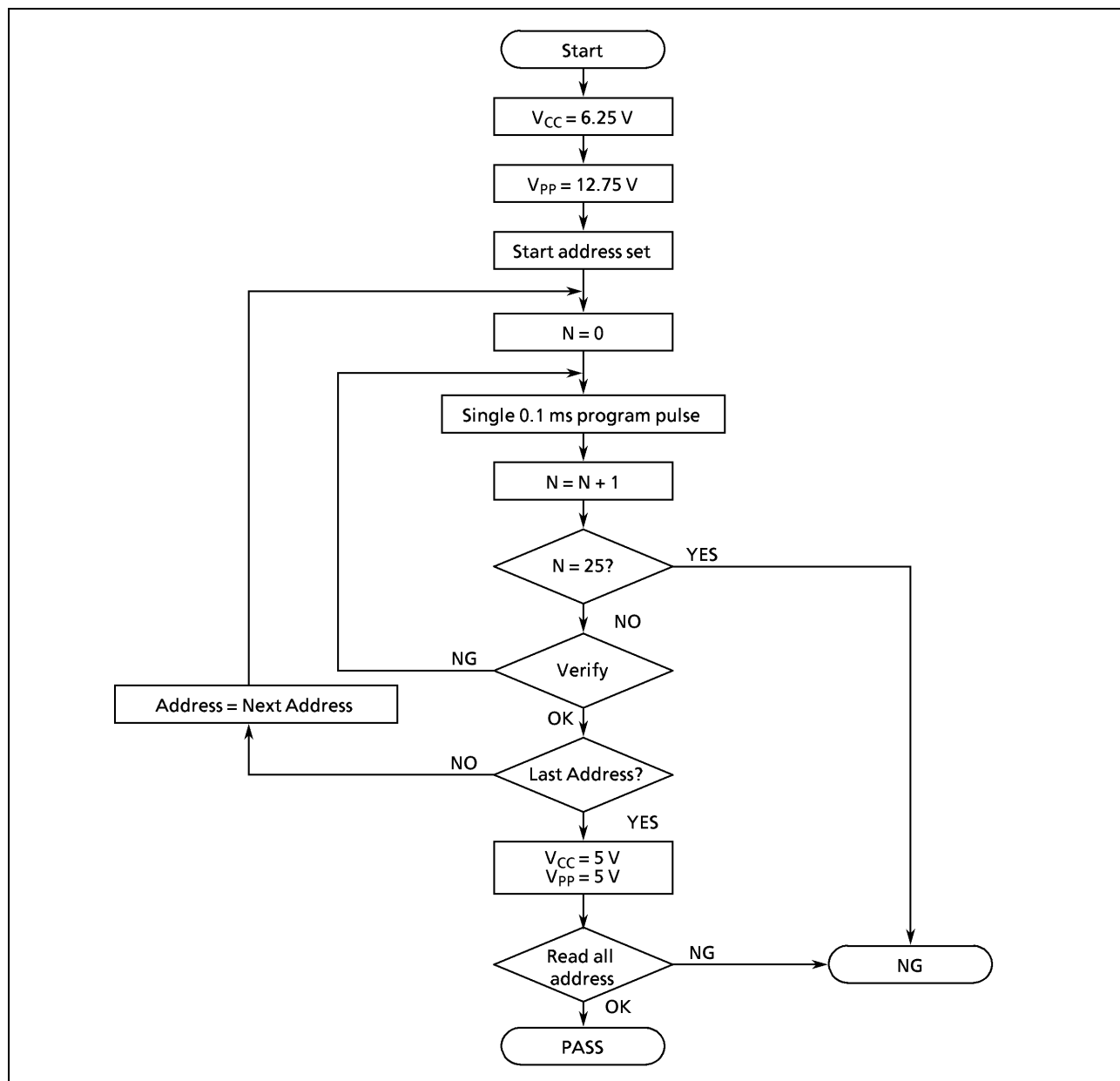


Figure 1-6. Flowchart of High-speed Programming Mode - II



### 1.2.3 Writing method for general-purpose PROM program

(1) Adapters

BM1136: TMP87PH00N

BM1137: TMP87PH00F

BM1173: TMP87PH00DF, 87PH00LF

(2) Adapter setting

Switch (SW1) is set to side N.

(3) PROM programmer specifying

i) PROM type is specified to TC57256AD.

Writing voltage: 12.5 V (high-speed program I mode)

12.75 V (high-speed program II mode)

ii) Data transfer (copy) (note 1)

In TMP87PH00, EPROM is within the addresses 4000 to 7FFFH. 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 16KB: transferred addresses C000 to FFFFH to addresses 4000 to 7FFFH

iii) Writing address is specified. (Caution 1)

Start address: 4000H

End address: 7FFFH

(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. The data in addresses 0000 to 3FFFH must be specified to FFH.*

*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: TMP87PH00 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 12 V  $\pm$  0.5 V to the address pin 9 (A9). The signature must not be used.*

## Electrical Characteristics

## Absolute Maximum Ratings

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

| Parameter                                   | Symbol              | Conditions                      | Ratings                        | Unit |
|---|---------------------|---------------------------------|--------------------------------|------|
| Supply Voltage                              | V <sub>DD</sub>     |                                 | – 0.3 to 7                     | V    |
| Program Voltage                             | V <sub>PP</sub>     | TEST / VPP                      | – 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>   | P0, P1, P2, P6, P7, XOUT, RESET | – 0.3 to V <sub>DD</sub> + 0.3 | V    |
|   | V <sub>OUT2</sub>   | P3, P4, P5                      | – 0.3 to 10                    |      |
| Output Current (Per 1 pin)                  | I <sub>OUT1</sub>   | P0, P1, P2, P4, P5, P6, P7      | 3.2                            | mA   |
|   | I <sub>OUT2</sub>   | P3                              | 30                             |      |
| Output Current (Total)                      | Σ I <sub>OUT1</sub> | P0, P1, P2, P4, P5, P6, P7      | 120                            | mA   |
|   | Σ I <sub>OUT2</sub> | P3                              | 120                            |      |
| Power Dissipation [T <sub>opr</sub> = 70°C] | PD                  | TMP87PH00N                      | 600                            | mW   |
|   |                     | TMP87PH00F / PH00DF             | 350                            |      |
| Soldering Temperature (time)                | T <sub>sld</sub>    |                                 | 260 (10 s)                     | °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> = 0 V, 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, Topr = – 30 to 70°C)

| Parameter                              | Symbol           | Pins                                 | Conditions   | Min | Typ. | Max | Unit |
|--|------------------|--------------------------------------|--|-----|------|-----|------|
| Hysteresis Voltage                     | V <sub>HS</sub>  | Hysteresis inputs                    | V <sub>DD</sub> = 5.0 V  | –   | 0.9  | –   | V    |
| Input Current                          | I <sub>IN1</sub> | TEST                                 | V <sub>DD</sub> = 5.5 V<br>V <sub>IN</sub> = 5.5 V / 0 V   | –   | –    | ± 2 | μA   |
|  | I <sub>IN2</sub> | Open drain ports,<br>tri-state ports |  |     |      |     |      |
|  | I <sub>IN3</sub> | RESET, STOP                          |  |     |      |     |      |
| Input Resistance                       | R <sub>IN2</sub> | RESET                                | V <sub>DD</sub> = 5.0 V  | 100 | 220  | 450 | kΩ   |
| Output Leakage Current                 | I <sub>LO1</sub> | Sink open drain ports                | V <sub>DD</sub> = 5.5 V, V <sub>OUT</sub> = 5.5 V  | –   | –    | 2   | μA   |
|  | I <sub>LO2</sub> | Tri-state ports                      | V <sub>DD</sub> = 5.5 V, V <sub>OUT</sub> = 5.5 V / 0 V  | –   | –    | ± 2 |      |
| Output High Voltage                    | V <sub>OH2</sub> | Tri- state ports                     | V <sub>DD</sub> = 4.5 V, I <sub>OH</sub> = – 0.7mA   | 4.1 | –    | –   | V    |
| Output Low Voltage                     | V <sub>OL</sub>  | Except XOUT and P3                   | V <sub>DD</sub> = 4.5 V, I <sub>OL</sub> = 1.6 mA  | –   | –    | 0.4 |      |
| Output Low Current                     | I <sub>OL3</sub> | Port P3                              | V <sub>DD</sub> = 4.5 V, V <sub>OL</sub> = 1.0 V   | –   | 20   | –   | mA   |
| Supply Current in<br>NORMAL 1, 2 modes | I <sub>DD</sub>  |                                      | V <sub>DD</sub> = 5.5 V<br>f <sub>c</sub> = 8 MHz<br>f <sub>s</sub> = 32.768 kHz<br>V <sub>IN</sub> = 5.3 V / 0.2 V  | –   | 8.5  | 12  | mA   |
| Supply Current in<br>IDLE 1, 2 modes   |                  |                                      |  | –   | 3.5  | 5   | mA   |
| Supply Current in<br>NORMAL 1, 2 modes |                  |                                      | V <sub>DD</sub> = 3.0 V, V <sub>IN</sub> = 2.8 V / 0.2 V<br>f <sub>c</sub> = 4.19 kHz<br>f <sub>s</sub> = 32.768 kHz | –   | 2.5  | 3.5 | mA   |
| Supply Current in<br>IDLE 1, 2 modes   |                  |                                      |  | –   | 1.5  | 2.0 | mA   |
| Supply Current in<br>SLOW mode         |                  |                                      | V <sub>DD</sub> = 3.0 V<br>f <sub>s</sub> = 32.768 kHz<br>V <sub>IN</sub> = 2.8 V / 0.2 V                            | –   | 30   | 60  | μA   |
| Supply Current in<br>SLEEP mode        |                  |                                      |  | –   | 15   | 30  | μA   |
| Supply Current in<br>STOP mode         |                  |                                      | V <sub>DD</sub> = 5.5 V<br>V <sub>IN</sub> = 5.3 V / 0.2 V   | –   | 0.5  | 10  | μA   |

Note 1: Typical value show those at Topr = 25°C.

Note 2: Input Current I<sub>IN1</sub>, I<sub>IN3</sub>; The current through resistor is not included, when the input resistor (pull-up or pull-down) is contained.

## A.C. Characteristics

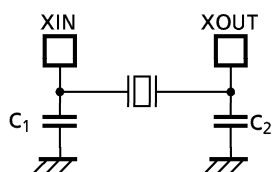
(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 4.5 to 6.0 V, T<sub>opr</sub> = – 30 to 70°C)

| 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), fc = 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), fs = 32.768 kHz | 14.7  | —    | —     | μs   |
| Low Level Clock Pulse Width  | t <sub>WSL</sub> |  |       |      |       |      |

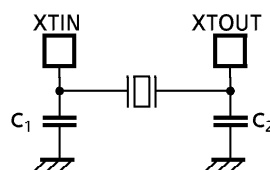
## Recommended Oscillating Conditions

(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 4.5 to 6.0 V, T<sub>opr</sub> = – 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                      | 30 pF                | 30 pF          |
|                            |                    | 4 MHz                 | KYOCERA KBR4.0MS<br>MURATA CSA4.00MG |                      |                |
|                            | Crystal Oscillator | 8 MHz                 | TOYOCOM 210B 8.0000                  | 20 pF                | 20 pF          |
|                            |                    | 4 MHz                 | TOYOCOM 204B 4.0000                  |                      |                |
| Low-frequency Oscillation  | Crystal Oscillator | 32.768 kHz            | NDK MX-38T                           | 15 pF                | 15 pF          |



(1) High-frequency Oscillation



(2) Low-frequency Oscillation

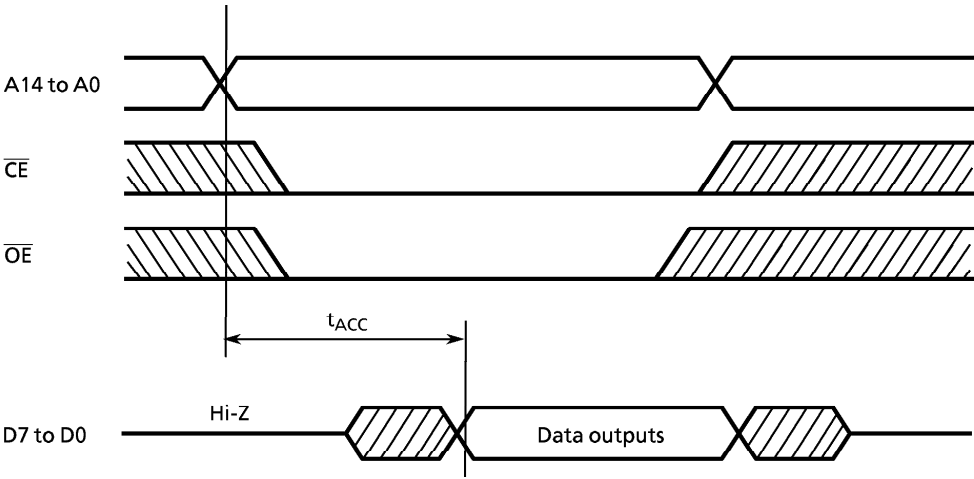
*Note: When used in high electric field such as a picture tube, the package is recommended to be electrically shielded to maintain a regular operation.*

D.C./A.C. Characteristics (PROM mode) (V<sub>SS</sub> = 0 V)

(1) Read Operation (T<sub>opr</sub> = – 30 to 70°C)

| Parameter                    | Symbol           | Conditions                     | Min                   | Typ.                      | Max                    | Unit |
|------------------------------|------------------|--------------------------------|-----------------------|---------------------------|------------------------|------|
| Input High Voltage           | V <sub>IH4</sub> |                                | V <sub>CC</sub> × 0.7 | –                         | V <sub>CC</sub>        | V    |
| Input Low Voltage            | V <sub>IL4</sub> |                                | 0                     | –                         | V <sub>CC</sub> × 0.12 | V    |
| Power Supply Voltage         | V <sub>CC</sub>  |                                | 4.75                  | 5.00                      | 5.25                   | V    |
| Program Power Supply Voltage | V <sub>PP</sub>  |                                | V <sub>CC</sub> – 0.6 | V <sub>CC</sub>           | V <sub>CC</sub> + 0.6  |      |
| Address Access Time          | t <sub>ACC</sub> | V <sub>CC</sub> = 5.0 ± 0.25 V | –                     | 1.5 t <sub>cy</sub> + 300 | –                      | ns   |

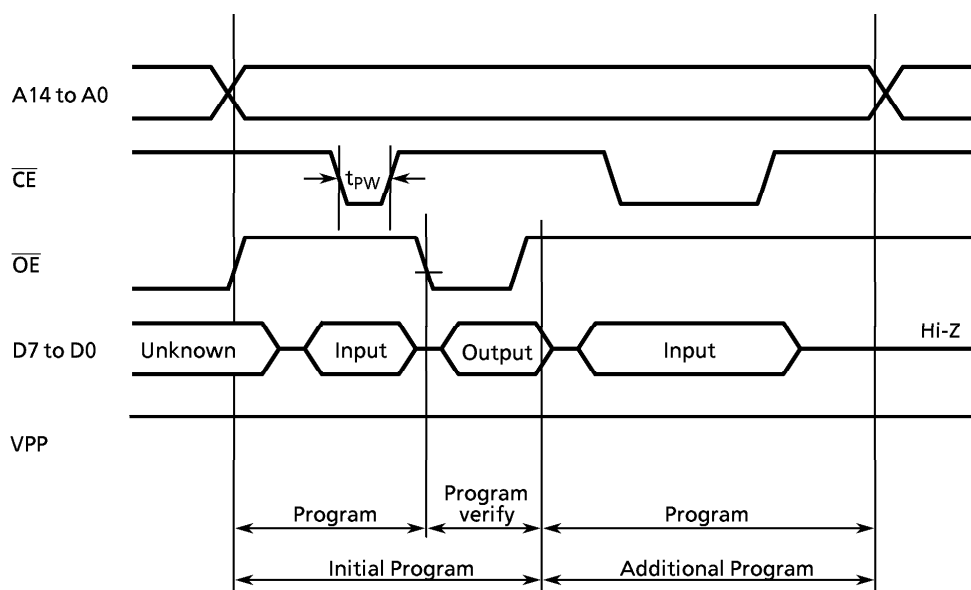
Note: t<sub>cy</sub> = 500 ns at 8 MHz



Timing Waveforms of Read Operation

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

| 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    |
| 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  | $t_{PW}$  | $V_{CC} = 6.0 \text{ V} \pm 0.25 \text{ V}$<br>$V_{PP} = 12.5 \pm 0.5 \text{ V}$ | 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.

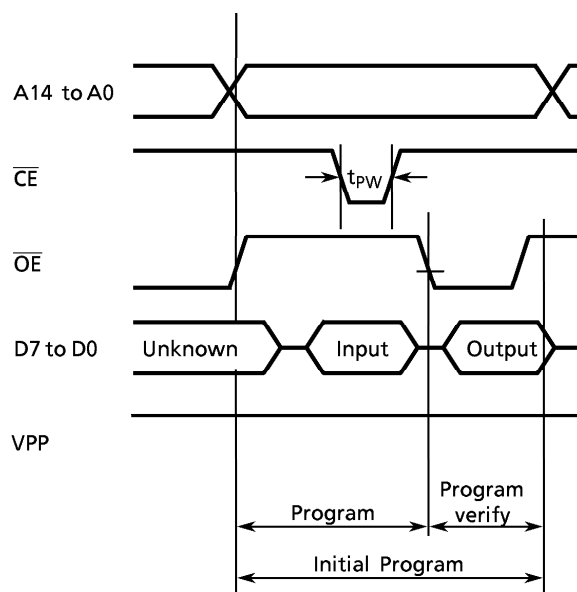
When  $V_{CC}$  power supply is turned off or before,  $V_{PP}$  must be decreased.

**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 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 programing mode with the recommended programing adaptor. If a mode or an adaptor except the above, the misoperation sometimes occurs.

## Electrical Characteristics

## Absolute Maximum Ratings

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

| Parameter                                   | Symbol              | Conditions                       | Ratings                        | Unit |
|---|---------------------|----------------------------------|--------------------------------|------|
| Supply Voltage                              | V <sub>DD</sub>     |                                  | – 0.3 to 6.5                   | V    |
| Program Voltage                             | V <sub>PP</sub>     | TEST / VPP 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>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, 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                  |                                  | 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                       | 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> = 0 V, 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                    | 5.5                    | V    |
|                    |                  |                          |                                | IDLE1, 2 mode          |                        |                        |      |
|                    |                  |                          | fc = 4.2 MHz                   | NORMAL1, 2 mode        | 1.8                    |                        |      |
|                    |                  |                          |                                | IDLE1, 2 mode          |                        |                        |      |
|                    |                  |                          | fs = 32.768 kHz                | SLOW mode              |                        |                        |      |
|                    |                  |                          |                                | SLEEP mode             |                        |                        |      |
|                    | STOP mode        |                          |                                |                        |                        |                        |      |
| Input High Voltage | V <sub>IH1</sub> | Except Hysteresis inputs | V <sub>DD</sub> ≥ 4.5 V        |                        | V <sub>DD</sub> × 0.7  | V <sub>DD</sub>        | V    |
|                    | V <sub>IH2</sub> | Hysteresis inputs        |                                |                        | 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 inputs | V <sub>DD</sub> ≥ 4.5 V        |                        | 0                      | V <sub>DD</sub> × 0.28 | V    |
|                    | V <sub>IL2</sub> | Hysteresis inputs        |                                |                        |                        | 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 5.5 V |                        | 0.4                    | 8.0                    | MHz  |
|                    |                  |                          | V <sub>DD</sub> = 1.8 to 4.5 V |                        |                        | 4.2                    |      |
|                    | fs               | XTIN, XOUT               |                                |                        | 30.0                   | 34.0                   | kHz  |

**Note:** 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.



## 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> = 5.0 V  | –   | 0.9  | –   | V    |
| Input Current                      | I <sub>IN1</sub> | TEST                                 | V <sub>DD</sub> = 5.5 V<br>V <sub>IN</sub> = 5.5 V / 0 V   | –   | –    | ± 2 | μA   |
|                                    | I <sub>IN2</sub> | Open drain ports and tri-state ports |  |     |      |     |      |
|                                    | I <sub>IN3</sub> | RESET, STOP                          |  |     |      |     |      |
| Input Low Current                  | I <sub>IL</sub>  | Push-pull ports                      | V <sub>DD</sub> = 5.5 V, V <sub>IN</sub> = 0.4 V   | –   | –    | – 2 | mA   |
| Input Resistance                   | R <sub>IN1</sub> | Port P7 with pull-up                 | V <sub>DD</sub> = 5.0 V  | 30  | 70   | 150 | kΩ   |
|                                    | R <sub>IN2</sub> | RESET                                | V <sub>DD</sub> = 5.0 V  | 100 | 220  | 450 |      |
| Output Leakage Current             | I <sub>LO1</sub> | Open drain ports                     | V <sub>DD</sub> = 5.5 V, V <sub>OUT</sub> = 5.5 V  | –   | –    | 2   | μA   |
|                                    | I <sub>LO2</sub> | Tri-state ports                      | V <sub>DD</sub> = 5.5 V, V <sub>OUT</sub> = 5.5 V / 0 V  | –   | –    | ± 2 |      |
| Output High Voltage                | V <sub>OH1</sub> | Push-pull ports                      | V <sub>DD</sub> = 4.5 V, I <sub>OH</sub> = – 200 μA  | 2.4 | –    | –   | V    |
|                                    | V <sub>OH2</sub> | Tri-state ports                      | V <sub>DD</sub> = 4.5 V, I <sub>OH</sub> = – 0.7 mA  | 4.1 | –    | –   |      |
|                                    | V <sub>OH3</sub> | Push-pull ports                      | V <sub>DD</sub> = 1.8 V, I <sub>OH</sub> = – 5 μA  | 1.6 | –    | –   |      |
| Output Low Voltage                 | V <sub>OL4</sub> | Tri-state ports                      | V <sub>DD</sub> = 1.8 V, I <sub>OH</sub> = – 10 μA   | 1.6 | –    | –   |      |
|                                    | V <sub>OL1</sub> | Except XOUT and port P3              | V <sub>DD</sub> = 4.5 V, I <sub>OL</sub> = 1.6 mA  | –   | –    | 0.4 |      |
|                                    | V <sub>OL2</sub> | Except XOUT                          | V <sub>DD</sub> = 1.8 V, I <sub>OL</sub> = 20 μA   | –   | –    | 0.2 |      |
| Output Low Current                 | I <sub>OL3</sub> | Port P3                              | V <sub>DD</sub> = 4.5 V, V <sub>OL</sub> = 1.0 V   | –   | 20   | –   | mA   |
| Supply Current in NORMAL 1, 2 mode | I <sub>DD</sub>  |                                      | V <sub>DD</sub> = 5.5 V<br>f <sub>c</sub> = 8 MHz<br>f <sub>s</sub> = 32.768 kHz<br>V <sub>IN</sub> = 5.3 V / 0.2 V    | –   | 7.0  | 10  |      |
| Supply Current in IDLE 1, 2 mode   |                  |                                      |  | –   | 3.5  | 5   |      |
| Supply Current in NORMAL 1, 2 mode |                  |                                      | V <sub>DD</sub> = 3.0 V<br>f <sub>c</sub> = 4.19 MHz<br>f <sub>s</sub> = 32.768 kHz<br>V <sub>IN</sub> = 2.8 V / 0.2 V | –   | 2.5  | 3.5 |      |
| Supply Current in IDLE 1, 2 mode   |                  |                                      |  | –   | 1.5  | 2.0 |      |
| Supply Current in NORMAL 1, 2 mode |                  |                                      | V <sub>DD</sub> = 1.8 V<br>f <sub>c</sub> = 4.19 MHz<br>f <sub>s</sub> = 32.768 kHz<br>V <sub>IN</sub> = 1.7 V / 0.1 V | –   | 1.0  | 2.0 |      |
| Supply Current in IDLE 1, 2 mode   |                  |                                      |  | –   | 0.5  | 1.0 |      |
| Supply Current in SLOW mode        |                  |                                      | V <sub>DD</sub> = 3.0 V<br>f <sub>s</sub> = 32.768 kHz<br>V <sub>IN</sub> = 2.8 V / 0.2 V                              | –   | 30   | 60  | μA   |
| Supply Current in SLEEP mode       |                  |                                      |  | –   | 15   | 30  |      |
| Supply Current in SLOW mode        |                  |                                      | V <sub>DD</sub> = 1.8 V<br>f <sub>s</sub> = 32.768 kHz<br>V <sub>IN</sub> = 1.7 V / 0.1 V                              | –   | 15   | 30  |      |
| Supply Current in SLEEP mode       |                  |                                      |  | –   | 10   | 20  |      |
| Supply Current in STOP mode        |                  |                                      | V <sub>DD</sub> = 5.5 V<br>V <sub>IN</sub> = 5.3 V / 0.2 V   | –   | 0.5  | 10  |      |

Note 1: Typical values show those at T<sub>opr</sub> = 25°C, V<sub>DD</sub> = 3V.

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

## A.C. Characteristics

(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 4.5 to 5.5 V, T<sub>opr</sub> = – 30 to 70°C)

| Parameter                    | Symbol           | Conditions   | Min   | Typ. | Max   | Unit |
|------------------------------|------------------|--|-------|------|-------|------|
| Machine Cycle Time           | t <sub>cy</sub>  | In NORMAL 1, 2 mode  | 0.5   | —    | 10    | μs   |
|                              |                  | In IDLE 1, 2 mode  |       |      |       |      |
|                              |                  | 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) , fc = 8.4 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), fs = 32.768 kHz | 14.7  | —    | —     | μs   |
| Low Level Clock Pulse Width  | t <sub>WSL</sub> |  |       |      |       |      |

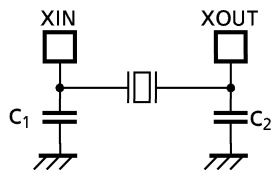
(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 1.8 to 4.5 V, T<sub>opr</sub> = – 30 to 70°C)

| Parameter                    | Symbol           | Conditions   | Min   | Typ. | Max   | Unit |
|------------------------------|------------------|--|-------|------|-------|------|
| Machine Cycle Time           | t <sub>cy</sub>  | In NORMAL 1, 2 mode  | 0.95  | —    | 10    | μs   |
|                              |                  | In IDLE 1, 2 mode  |       |      |       |      |
|                              |                  | 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) , fc = 4.2 MHz    | 110   | —    | —     | 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), fs = 32.768 kHz | 14.7  | —    | —     | μs   |
| Low Level Clock Pulse Width  | t <sub>WSL</sub> |  |       |      |       |      |

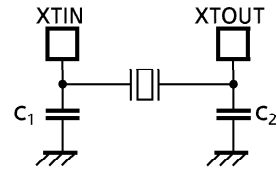
## Recommended Oscillating Conditions

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

| Parameter      | Oscillator         | Oscillation Frequency                          | Recommended Oscillator |            | Recommended Constant |                |
|----------------|--------------------|--|------------------------|------------|----------------------|----------------|
|                |                    |  |                        |            | C <sub>1</sub>       | C <sub>2</sub> |
| High-frequency | Ceramic Resonator  | 4.19 MHz<br>(V <sub>DD</sub> = 1.8 to 5.5 V)   | MURATA                 | CSA4.19MG  | 30 pF                | 30 pF          |
|                |                    |  | MURATA                 | CST4.19MGW | —                    | —              |
|                |                    | 8 MHz<br>(V <sub>DD</sub> = 4.5 to 5.5 V)      | MURATA                 | CSA8.00MTZ | 15 pF                | 15 pF          |
|                |                    |  | MURATA                 | CST8.00MTW | —                    | —              |
|                | Crystal Oscillator | 8 MHz<br>(V <sub>DD</sub> = 4.5 to 5.5 V)      | NDK                    | AT-51      | 16 pF                | 16 pF          |
| Low-frequency  | Crystal Oscillator | 32.768 kHz<br>(V <sub>DD</sub> = 1.8 to 5.5 V) | NDK                    | MX-38T     | 12 pF                | 12 pF          |



(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.*

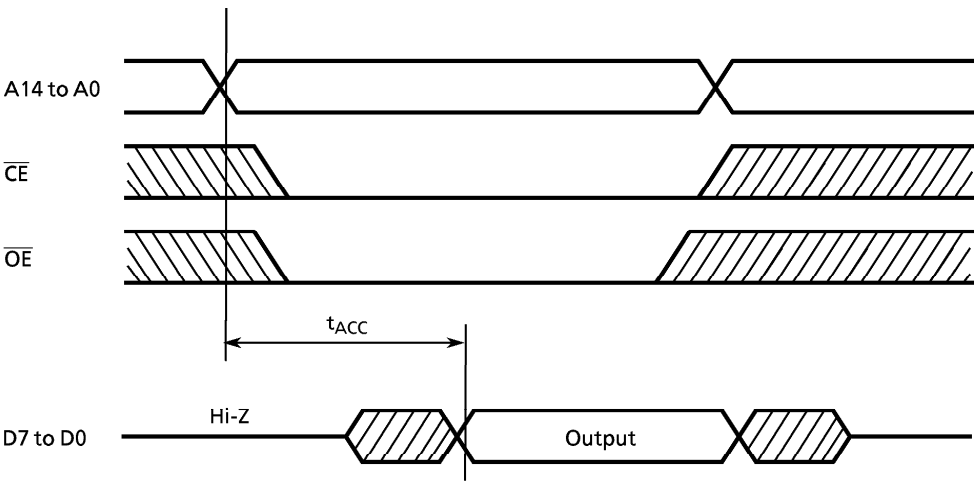
D.C./A.C. Characteristics (PROM mode)

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

(1) Read Operation (T<sub>opr</sub> = – 30 to 70 °C)

| Parameter                    | Symbol           | Conditions                     | Min                   | Typ.                       | Max                    | Unit |
|------------------------------|------------------|--------------------------------|-----------------------|----------------------------|------------------------|------|
| Input High Voltage           | V <sub>IH4</sub> |                                | V <sub>CC</sub> × 0.7 | –                          | V <sub>CC</sub>        | V    |
| Input Low Voltage            | V <sub>IL4</sub> |                                | 0                     | –                          | V <sub>CC</sub> × 0.12 | V    |
| Power Supply Voltage         | V <sub>CC</sub>  |                                | 4.75                  | 5.00                       | 5.25                   | V    |
| Program Power Supply Voltage | V <sub>PP</sub>  |                                | V <sub>CC</sub> – 0.6 | V <sub>CC</sub>            | V <sub>CC</sub> + 0.6  |      |
| Address Access Time          | t <sub>ACC</sub> | V <sub>CC</sub> = 5.0 ± 0.25 V | –                     | 1.5 t <sub>cyc</sub> + 300 | –                      | ns   |

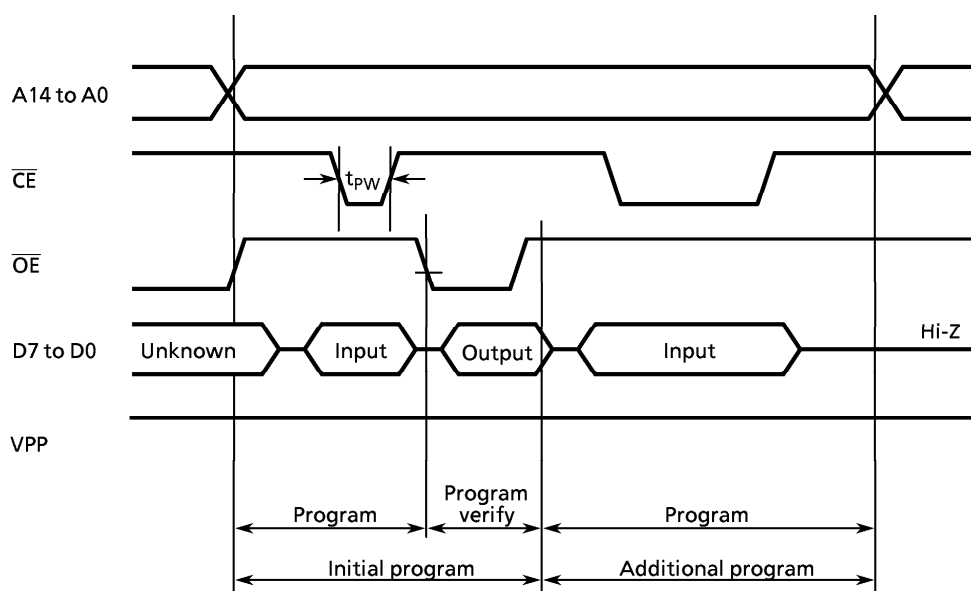
Note: t<sub>cyc</sub> = 500 ns at 8 MHz



Timing Waveforms of Read Operation

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

| 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    |
| 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  | $t_{PW}$  | $V_{CC} = 6.0 \text{ V} \pm 0.25 \text{ V}$<br>$V_{PP} = 12.5 \text{ V} \pm 0.5 \text{ V}$ | 0.95                | 1.0  | 1.05                 | ms   |



Timing Waveforms of Programming Operation

**Note1:** When  $V_{CC}$  power supply is turned on or after,  $V_{PP}$  must be increased.

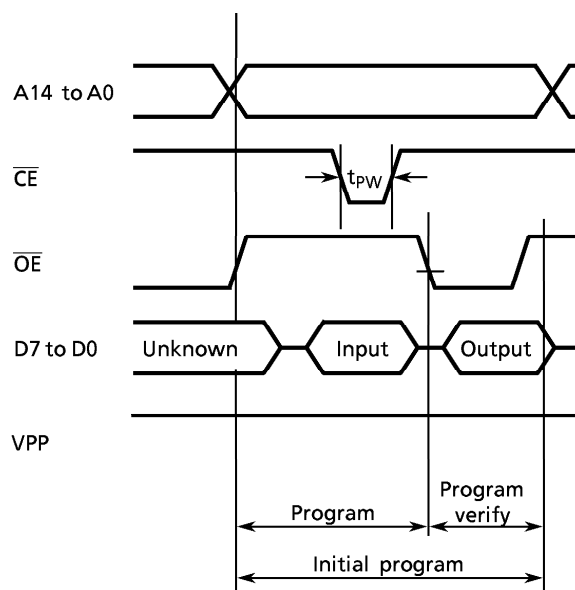
When  $V_{CC}$  power supply is turned off or before,  $V_{PP}$  must be decreased.

**Note2:** 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.

**Note3:** 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   |



**Note1:** 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.

**Note2:** 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.

**Note3:** 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.