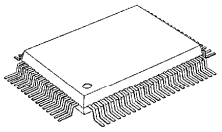
CMOS 8-BIT MICROCONTROLLER

# TMP87PM70F

The 87PM70 is a One-Time PROM microcontroller with low-power 256K bits (32K bytes) electrically programmable read only memory for the 87CH70B/CM70B system evaluation. The 87PM70 is pin compatible with the 87CH70B/CM70B. The operations possible with the 87CH70B/CM70B can be performed by writing programs to PROM. The 87PM70 can write and verify in the same way as the TC57256AD using an adaptor socket BM1150 and an EPROM programmer.

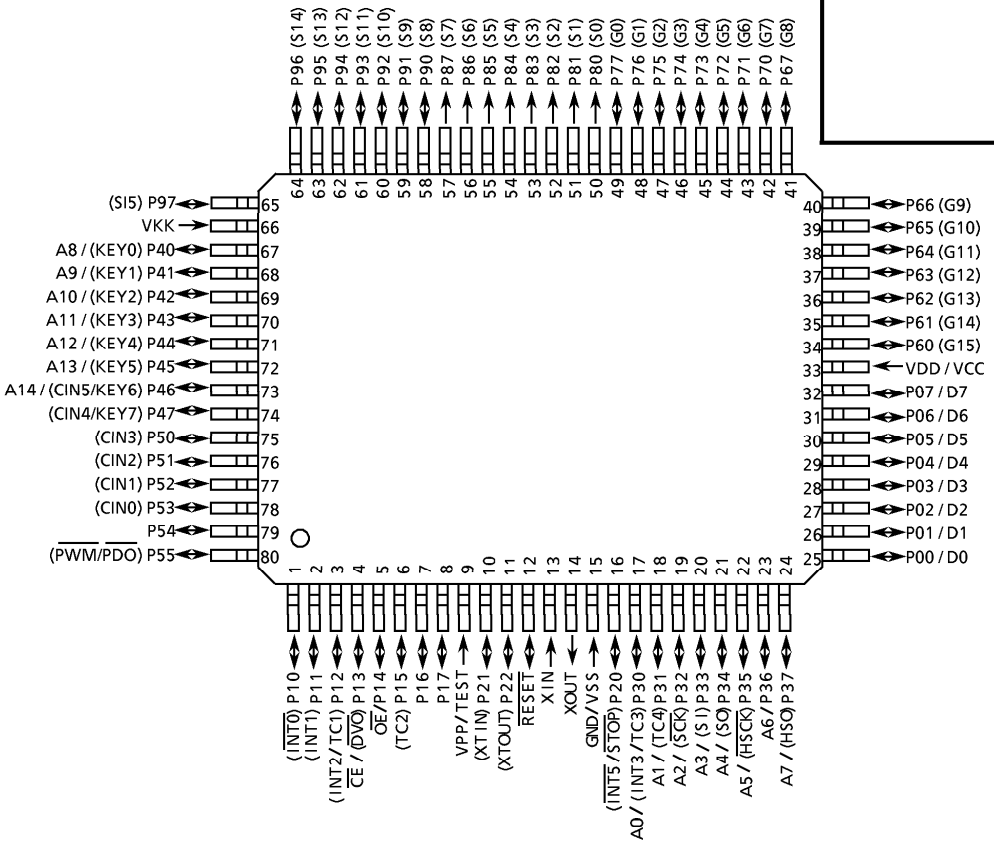
| PART No. | OTP | RAM | PACKAGE | ADAPTER SOCKET |
|---|---|---|---|---|
| TMP87PM70F | 32K × 8-bit | 512 × 8-bit | QFP80 | BM1150B |

QFP80-P-1420B



TMP87PM70F

**PIN ASSIGNMENTS** (TOP VIEW)



## PIN FUNCTION

The 87PM70 has two modes: MCU and PROM.

(1) MCU mode

In this mode, the 87PM70 is pin compatible with the 87CH70B/CM70B (fix the TEST pin at low level).

(2) PROM mode

| PIN NAME (PROM mode) | INPUT/OUTPUT | FUNCTIONS | PIN NAME (MCU mode) |
|---|---|---|---|
| A14 to A8 | Input | PROM address inputs | P46 to P40 |
| A7 to A0 | | | P37 to P30 |
| 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 | + 12.5 V / 5 V (Program supply voltage) | TEST |
| VCC | | + 5 V | VDD |
| GND | | 0 V | VSS |
| P55 to P50 | I/O | Pull-down with resistance for input processing | |
| P11 | | PROM mode setting pin. Be fixed at high level. | |
| P21 | | | |
| P47 | | | |
| P17 to P15 | | PROM mode setting pin. Be fixed at low level. | |
| P12, P10 | | | |
| P22, P20 | | | |
| $\overline{RESET}$ | | | |
| XIN | Input | Connect an 8 MHz oscillator to stabilize the internal state. | |
| XOUT | Output | | |
| VKK | VFT power supply | GND | |
| P97 to P90 | I/O | Open | |
| P87 to P80 | Output | | |
| P77 to P70 | I/O | | |
| P67 to P60 | | | |

## OPERATIONAL DESCRIPTION

The following explains the 87PM70 hardware configuration and operation. The configuration and functions of the 87PM70 are the same as those of the 87CH70B/CM70B, except in that a one-time PROM is used instead of an on-chip mask ROM.

The 87PM70 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 87PM70 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 87CH70B/CM70B (the TEST / VPP pin cannot be used open because it has no built-in pull-down resistance).

#### 1.1.1 Program Memory

The 87PM70 has a 32K × 8-bit (addresses $8000_H$-$FFFF_H$ in the MCU mode, addresses $0000_H$-$7FFF_H$ in the PROM mode) of program memory (OTP).

To use the 87PM70 as the system evaluation for the 87CH70B/M70B, the program should be written to the program memory area as shown in Figure 1-1.

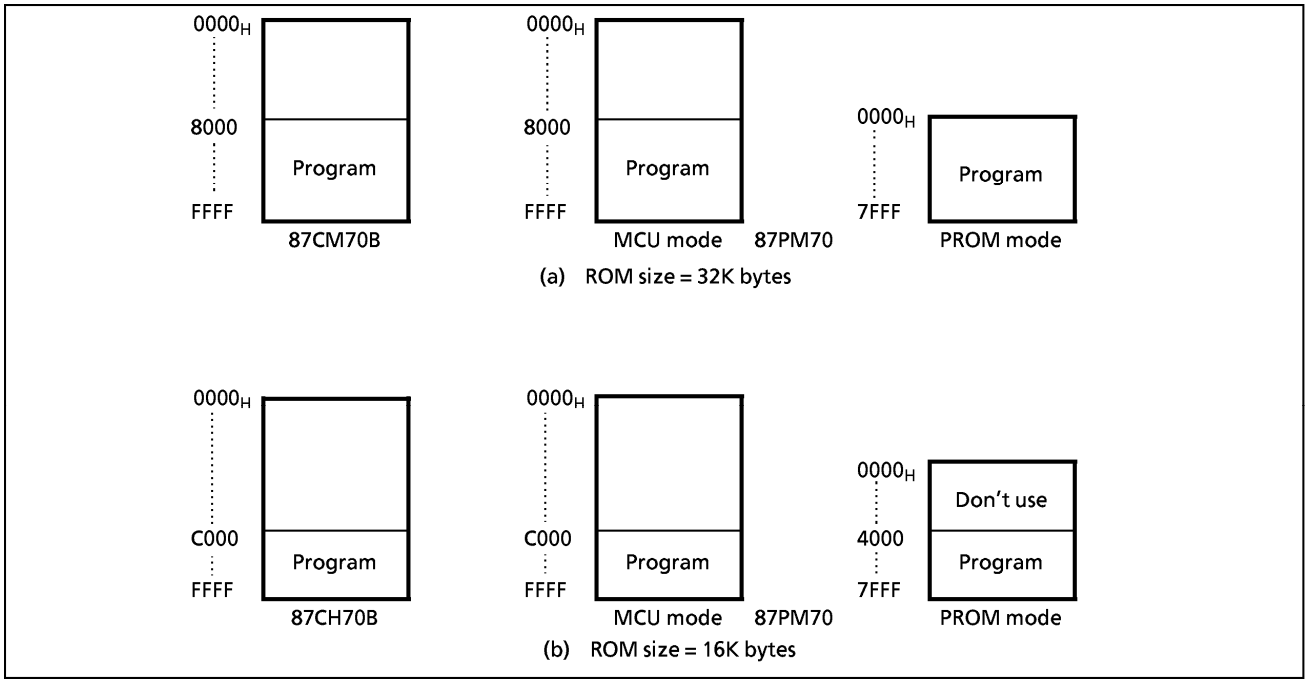



Figure 1-1. Program Memory Area

Either write the data $FF_H$ to the unused area or set the PROM programmer to access only the program storage area.

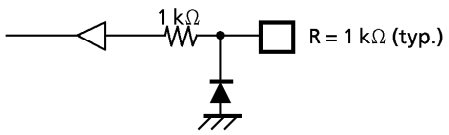
### 1.1.2 Data Memory

The 87PM70 has an on-chip 512 × 8-bit data memory (static RAM).

### 1.1.3 Input/Output Circuitry

(1) Control pins

The control pins of the 87PM70 are the same as those of the 87CH70B/CM70B except that the TEST pin has is no built-in pull-down resistance.




*Note : TEST pin has no built-in pull-down resistance*

Figure 1-2. TEST pin

(2) I/O ports

The 87PM70 I/O ports of the I/O circuitry is the same as that of the 87CH70B/CM70B.

## 1.2 PROM mode

The PROM mode is activated by setting the pins TEST, $\overline{RESET}$ and the ports P17-P10, P22-P20 and P47 as shown in Figure 1-2. 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 87PM70 is not supported an electric signature mode, so the ROM type must be set to TC57256AD.
Set the adaptor socket switch to "N".

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

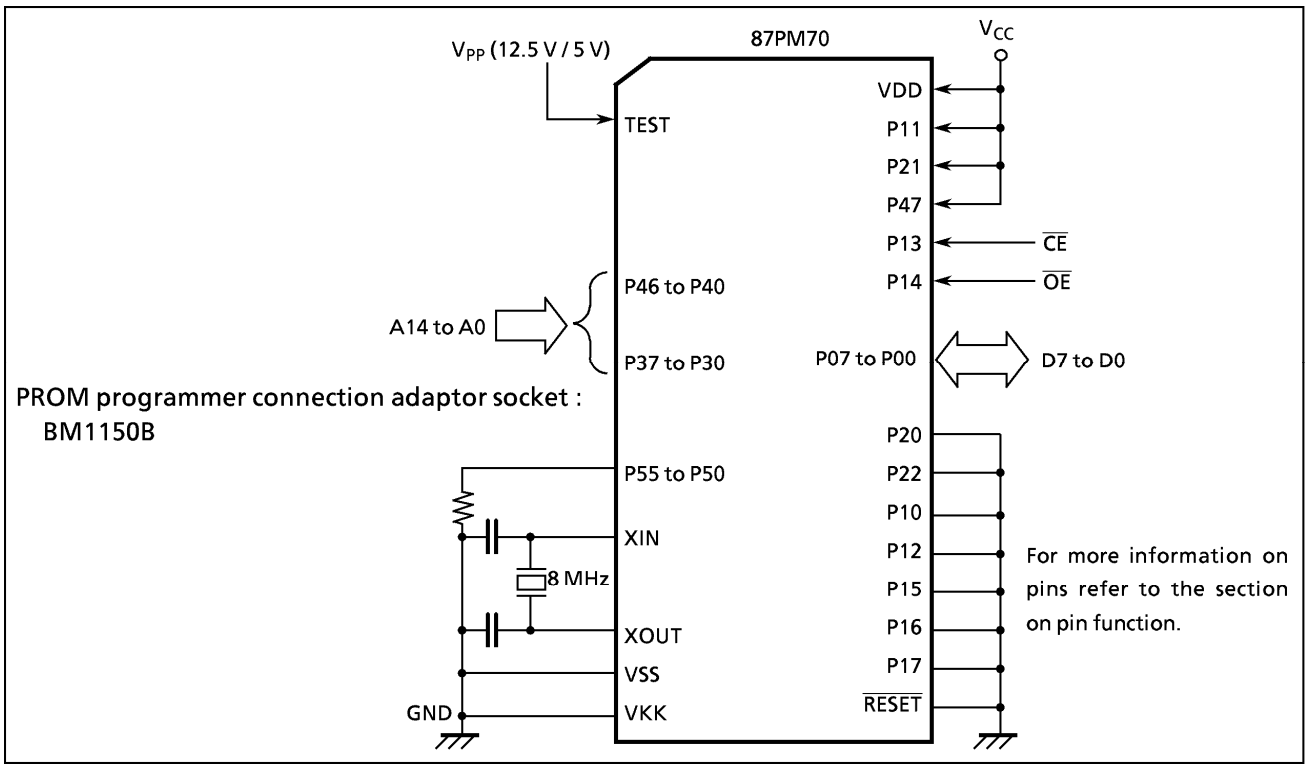



Figure 1-3. Setting for PROM Mode

### 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 × 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.

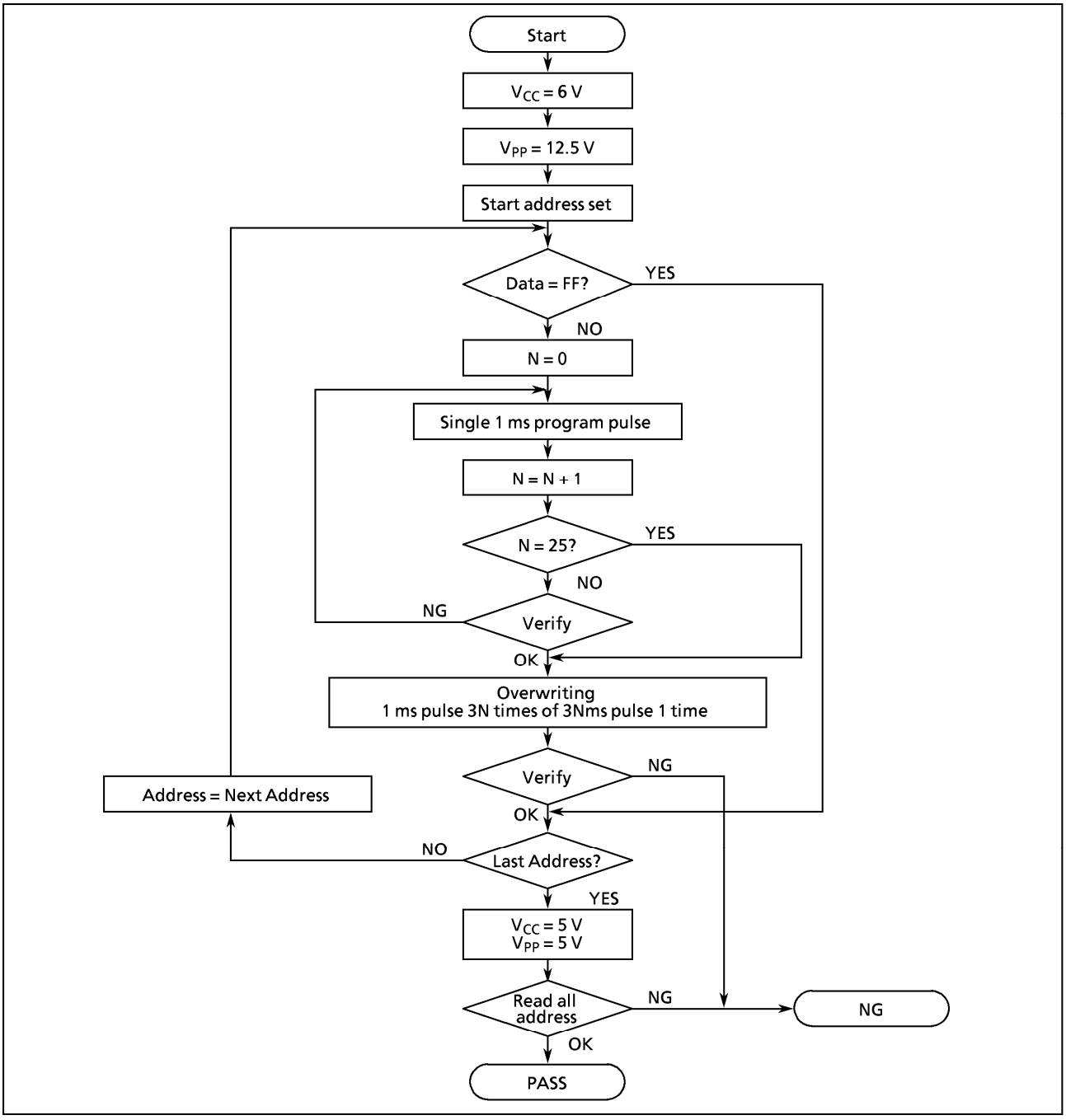



Figure 1-4. Flowchart of High-speed Programming Mode - I

### 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.

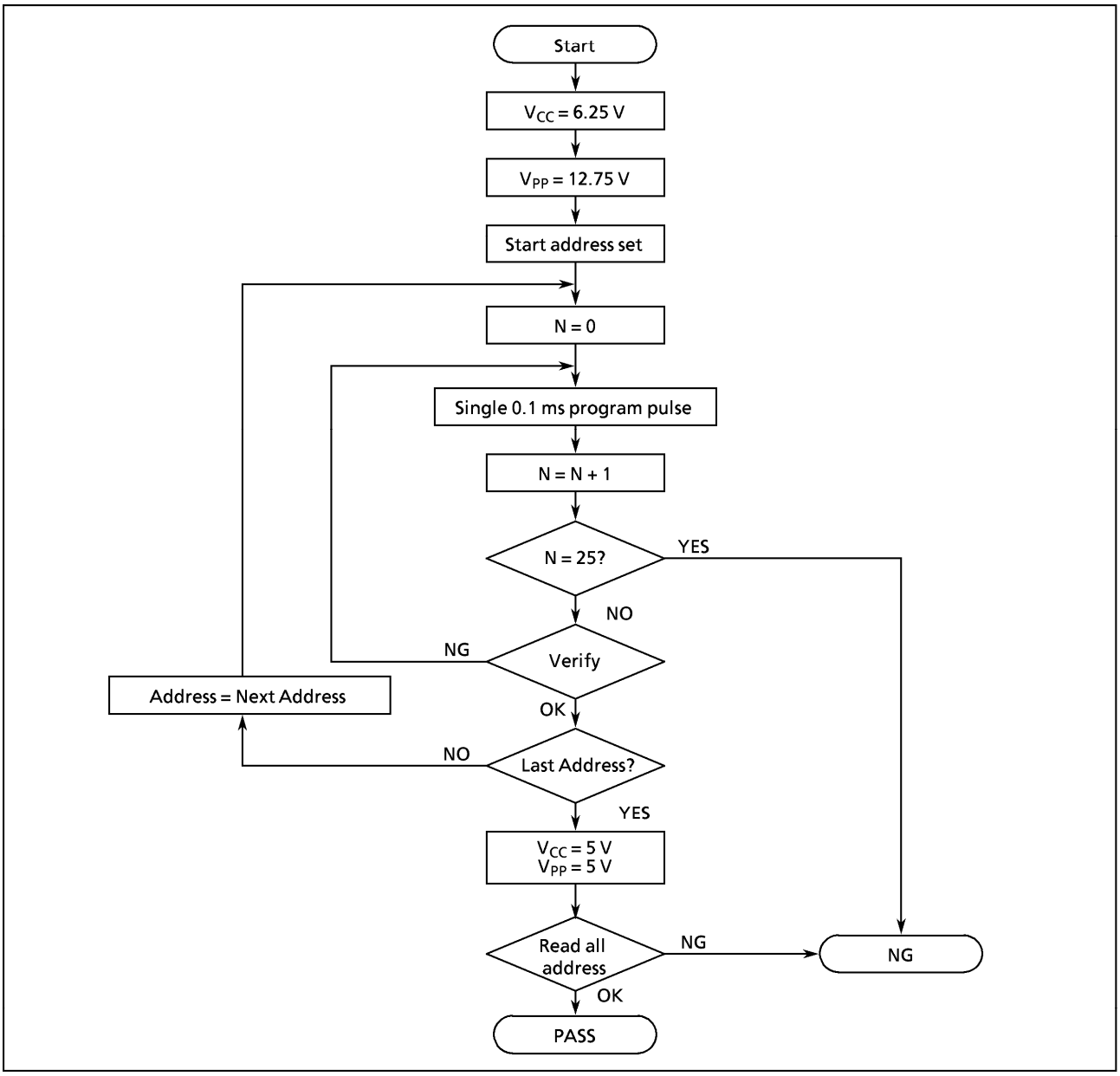



Figure 1-5. Flowchart of High-speed Programming Mode - II

### 1.2.3 Writing Method for General-purpose PROM Program

(1) Adapters
BM1150B : TMP87PM70F

(2) Adapter setting
Switch (SW1) is set to side N.
Switch (SW2) is set to side PM70.

(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 TMP87PM70, EPROM is within the addresses 0000 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 32KB : transferred addresses 8000 to FFFFH to addresses 0000 to 7FFFH

iii) Writing address is specified. (note 1)
Start address : 0000H
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 unused area must be specified to $FF_H$.*

*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 : TMP87PM70 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 ± 0.5 V to the address pin 9 (A9). The signature must not be used.*

## ELECTRICAL CHARACTERISTICS

### ABSOLUTE MAXIMUM RATINGS ($V_{SS}$ = 0 V)

| PARAMETER | SYMBOL | CONDITIONS | RATINGS | UNIT |
|---|---|---|---|---|
| Supply Voltage | $V_{DD}$ | | – 0.3~7 | V |
| Program Voltage | $V_{PP}$ | TEST / VPP | – 0.3 to 13.0 | V |
| Input Voltage | $V_{IN}$ | | – 0.3 to $V_{DD}$ + 0.3 | V |
| Output Voltage | $V_{OUT1}$ | P2, P4, P5, XOUT | – 0.3 to $V_{DD}$ + 0.3 | V |
| | $V_{OUT2}$ | P3 | – 0.3 to 10 | |
| | $V_{OUT3}$ | Source open drain ports | $V_{DD}$ – 40 to $V_{DD}$ + 0.3 | |
| Output Current (Per 1 pin) | $I_{OUT1}$ | P0, P1, P2, P3, P4, P5 | 3.2 | mA |
| | $I_{OUT3}$ | P8, P9 (segment output) | – 12 | |
| | $I_{OUT4}$ | P6, P7 (digit output) | – 25 | |
| Output Current (Total) | $\Sigma I_{OUT1}$ | P0, P1, P2, P3, P4, P5 | 120 | mA |
| | $\Sigma I_{OUT2}$ | P6, P7, P8, P9 | – 120 | |
| Power Dissipation [Topr = 70 °C] | PD | | 350 | mW |
| Soldering Temperature (time) | Tsld | | 260 (10 s) | °C |
| Storage Temperature | Tstg | | – 55 to 125 | °C |
| Operating Temperature | Topr | | – 30 to 70 | °C |

### RECOMMENDED OPERATING CONDITIONS ($V_{SS}$ = 0 V, Topr = – 30 to 70 °C)

| PARAMETER | SYMBOL | PINS | CONDITIONS | Min. | Max. | UNIT |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{DD}$ | | NORMAL1, 2 modes | 4.5 | 6.0 | V |
| | | | IDLE1, 2 modes | | | |
| | | | SLOW mode | 2.7 | | |
| | | | SLEEP mode | | | |
| | | | STOP mode | 2.0 | | |
| Input High Voltage | $V_{IH1}$ | Except hysteresis input | $V_{DD} \geqq 4.5$ V | $V_{DD} \times 0.70$ | $V_{DD}$ | V |
| | $V_{IH2}$ | Hysteresis input | | $V_{DD} \times 0.75$ | | |
| | $V_{IH3}$ | | $V_{DD} < 4.5$ V | $V_{DD} \times 0.90$ | | |
| Input Low Voltage | $V_{IL1}$ | Except hysteresis input | $V_{DD} \geqq 4.5$ V | 0 | $V_{DD} \times 0.30$ | V |
| | $V_{IL2}$ | Hysteresis input | | | $V_{DD} \times 0.25$ | |
| | $V_{IL3}$ | | $V_{DD} < 4.5$ V | | $V_{DD} \times 0.10$ | |
| Clock Frequency | fc | XIN, XOUT | | 0.4 | 8.0 | MHz |
| | fs | XTIN, XTOUT | | 30.0 | 34.0 | kHz |

*Note 1 : Power supply voltage $V_{DD}$: At fc = 8 MHz, fs = 32.768 kHz*
*Note 2 : Input Voltage $V_{IH3}$ $V_{IL3}$; In SLOW, SLEEP or STOP mode*

## D.C. CHARACTERISTICS

($V_{SS}$ = 0 V, Topr = – 30 to 70 °C)

| PARAMETER | SYMBOL | PINS | CONDITIONS | Min. | Typ. | Max. | UNIT |
|---|---|---|---|---|---|---|---|
| Hysteresis Voltage | $V_{HS}$ | Hysteresis inputs | | – | 0.9 | – | V |
| Input Current | $I_{IN1}$ | TEST | $V_{DD}$ = 5.5 V<br>$V_{IN}$ = 5.5 V/0 V | – | – | ± 2 | μA |
| | $I_{IN2}$ | Open drain ports, Tri-state ports | | | | | |
| | $I_{IN3}$ | $\overline{RESET}$, $\overline{STOP}$ | | | | | |
| Input Resistance | $R_{IN1}$ | Port P4 with pull-down | | 30 | 70 | 150 | kΩ |
| | $R_{IN2}$ | $\overline{RESET}$ | | 100 | 220 | 450 | |
| Pull-down Resistance | $R_K$ | Source open drain ports | $V_{DD}$ = 5.5 V, $V_{KK}$ = – 30 V | – | 80 | – | |
| Output Leakage Current | $I_{LO1}$ | Sink open drain ports | $V_{DD}$ = 5.5 V, $V_{OUT}$ = 5.5 V | – | – | 2 | μA |
| | $I_{LO2}$ | Source open drain | $V_{DD}$ = 5.5 V, $V_{OUT}$ = – 32 V | – | – | – 2 | |
| | $I_{LO3}$ | Tri-state ports | $V_{DD}$ = 5.5 V, $V_{OUT}$ = 5.5 V/0 V | – | – | ± 2 | |
| Output High Voltage | $V_{OH2}$ | Tri-state ports | $V_{DD}$ = 4.5 V, $I_{OH}$ = – 0.7 mA | 4.1 | – | – | V |
| | $V_{OH3}$ | P8, P9 | $V_{DD}$ = 4.5 V, $I_{OH}$ = – 5 mA | 2.4 | – | – | |
| Output Low Voltage | $V_{OL}$ | Except XOUT | $V_{DD}$ = 4.5 V, $I_{OL}$ = 1.6 mA | – | – | 0.4 | V |
| Output High current | $I_{OH}$ | P6, P7 | $V_{DD}$ = 4.5 V, $V_{OH}$ = 2.4 V | – | – 15 | – | mA |
| Supply Current in NORMAL 1, 2 modes | $I_{DD}$ | | $V_{DD}$ = 5.5 V<br>fc = 8 MHz | – | 12 | 18 | mA |
| Supply Current in IDLE 1, 2 modes | | | fs = 32.768 kHz<br>$V_{IN}$ = 5.3 V/0.2 V | – | 4.5 | 6 | |
| Supply Current in SLOW mode | | | $V_{DD}$ = 3.0 V<br>fs = 32.768 kHz | – | 30 | 60 | μA |
| Supply Current in SLEEP mode | | | $V_{IN}$ = 2.8 V/0.2 V | – | 15 | 30 | |
| Supply Current in STOP mode | | | $V_{DD}$ = 5.5 V<br>$V_{IN}$ = 5.3 V/0.2 V | – | 0.5 | 10 | μA |

*Note 1 : Typical values show those at Topr = 25 °C , $V_{DD}$ = 5 V.*

*Note 2 : Input Current $I_{IN1}$, $I_{IN3}$ ; The current through resistor is not included, when the input resistor (pull-up or pull-down) is contained.*

*Note 3: Typical current consumption during A/D conversion is 1.2 mA.*

## A/D CONVERSION CHARACTERISTICS

($V_{SS}$ = 0 V, $V_{DD}$ = 4.5 to 6.0 V, Topr = – 30 to 70 °C)

| PARAMETER | SYMBOL | PINS | CONDITIONS | Min. | Typ. | Max. | UNIT |
|---|---|---|---|---|---|---|---|
| Analog Input Voltage Range | $V_{AIN}$ | CIN5 to CIN0 | | $V_{SS}$ | – | $V_{DD}$ | V |
| Conversion Error | | | $V_{DD}$ = 5.0 V | – | – | ± 1.5 | LSB |

## A.C. CHARACTERISTICS

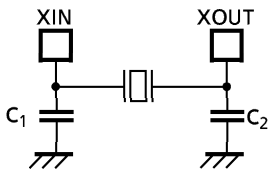
($V_{SS}$ = 0 V, $V_{DD}$ = 4.5 to 6.0 V, Topr = – 30 to 70 °C)

| PARAMETER | SYMBOL | CONDITIONS | Min. | Typ. | Max. | UNIT |
|---|---|---|---|---|---|---|
| Machine Cycle Time | $t_{cy}$ | 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 | $t_{WCH}$ | For external clock operation (XIN input), fc = 8 MHz | 50 | – | – | ns |
| Low Level Clock Pulse Width | $t_{WCL}$ | | | | | |
| High Level Clock Pulse Width | $t_{WSH}$ | For external clock operation (XTIN input), fs = 32.768 kHz | 14.7 | – | – | μs |
| Low Level Clock Pulse Width | $t_{WSL}$ | | | | | |

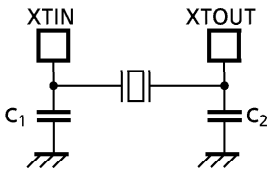
## RECOMMENDED OSCILLATING CONDITIONS

($V_{SS}$ = 0 V, $V_{DD}$ = 4.5 to 6.0 V, Topr = – 30 to 70 °C)

| PARAMETER | Oscillator | Oscillation Frequency | Recommended Oscillator | | Recommended Constant $C_1$ | Recommended Constant $C_2$ |
|---|---|---|---|---|---|---|
| High-frequency Oscillation | Ceramic Resonator | 8 MHz | KYOCERA | KBR8.0M | 30 pF | 30 pF |
| | | 4 MHz | KYOCERA | KBR4.0MS | | |
| | | | 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

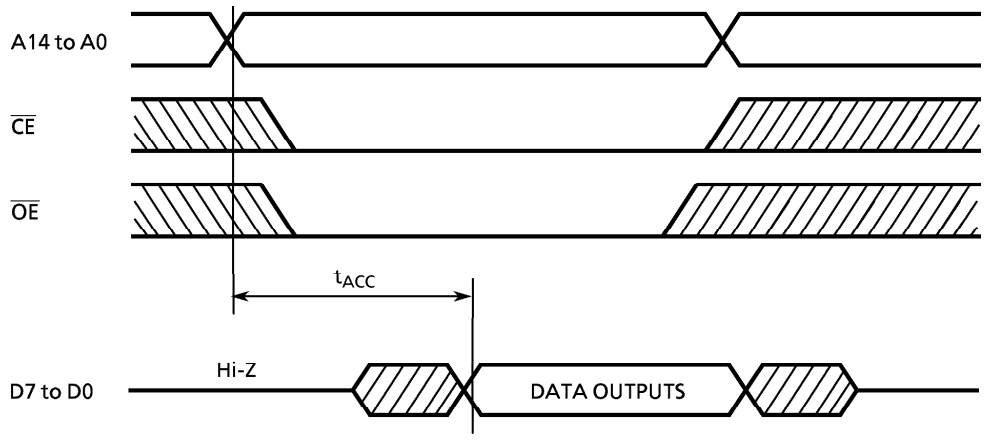
*Note : An electrical shield by metal shield plate on the surface of the IC package should be recommendable in order to prevent the device from the high electric fieldstress applied for continuous reliable operation.*

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

(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 | – | 6.0 | V |
| Program Power Supply Voltage | $V_{PP}$ | | | | | |
| Address Access Time | $t_{ACC}$ | $V_{CC}$ = 5.0 ± 0.25 V | – | 1.5tcyc + 300 | – | ns |

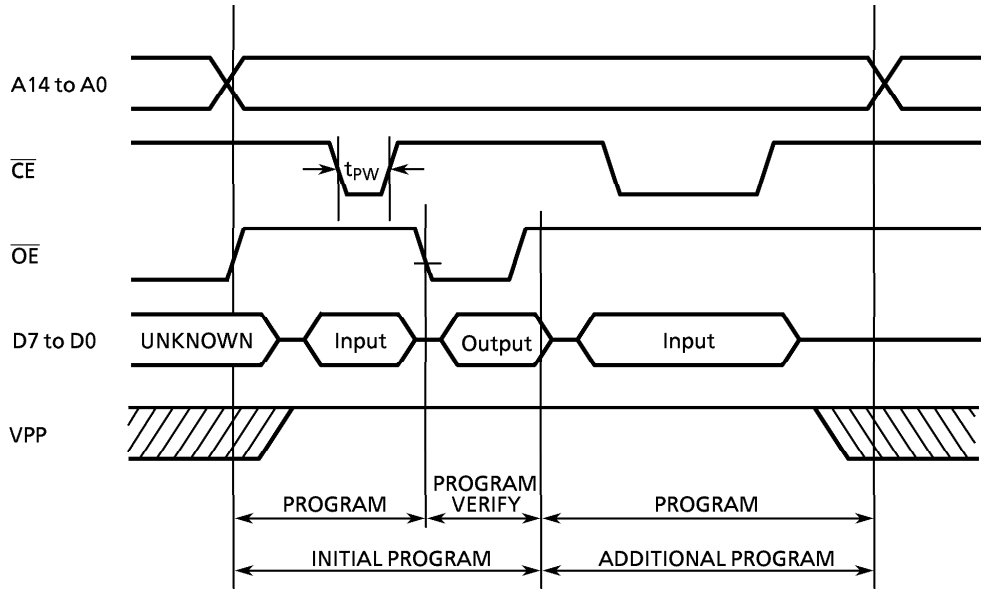
*Note : tcyc = 500 ns at 8 MHz*




TIMING WAVEFORMS OF READ OPERATION

(2) Program Operation (High-Speed program mode-Ⅰ) (Topr = 25 ± 5 °C)

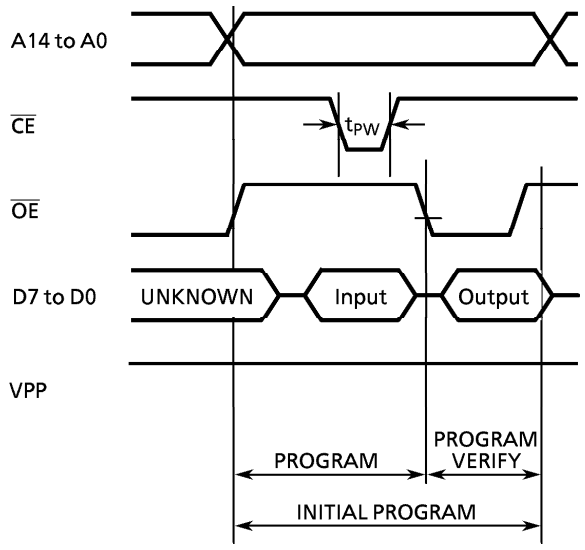
| PARAMETER | SYMBOL | CONDITIONS | Min. | Typ. | Max. | UNIT |
|---|---|---|---|---|---|---|
| Input High Voltage | $V_{IH4}$ | | $V_{CC} \times 0.7$ | – | $V_{CC}$ | V |
| Input Low Voltage | $V_{IL4}$ | | 0 | – | $V_{CC} \times 0.12$ | V |
| Power Supply Voltage | $V_{CC}$ | | 5.75 | 6.0 | 6.25 | 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 ± 0.25 V<br>$V_{PP}$ = 12.5 ± 0.5 V | 0.95 | 1.0 | 1.05 | ms |




| | |
|---|---|
| *Note1:* | *When $V_{cc}$ power supply is turned on or after, $V_{pp}$ must be increased.*<br>*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 V ± 0.5 V) to the $V_{pp}$ pin as the device is damaged.* |
| *Note3:* | *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.* |

(3) Program Operation (High-Speed program mode-II) (Topr = 25 ± 5 °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 V ± 0.25 V, $V_{PP}$ = 12.75 ± 0.25 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 (12.5 V ± 0.5 V) to the $V_{pp}$ pin as the device is damaged.*
*Note3: 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.*