

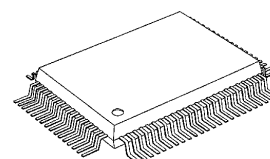
## CMOS 8-Bit Microcontroller

## TMP87PM53F

The 87PM53 is a One-Time PROM microcontroller with low-power 256 K bits electrically programmable read only memory for the 87CM53 system evaluation. The 87PM53 is pin compatible with the 87CM53. The operations possible with the 87CM53 can be performed by writing programs to PROM. The 87PM53 can write and verify in the same way as the TC571000D using an adaptor socket BM11104 and an EPROM programmer.

| Part No.   | OTP          | RAM         | Package            | OTP Adapter |
|------------|--------------|-------------|--------------------|-------------|
| TMP87PM53F | 32 K × 8-bit | 1 K × 8-bit | P-QFP80-1420-0.80B | BM11104     |

P-QFP80-1420-0.80B

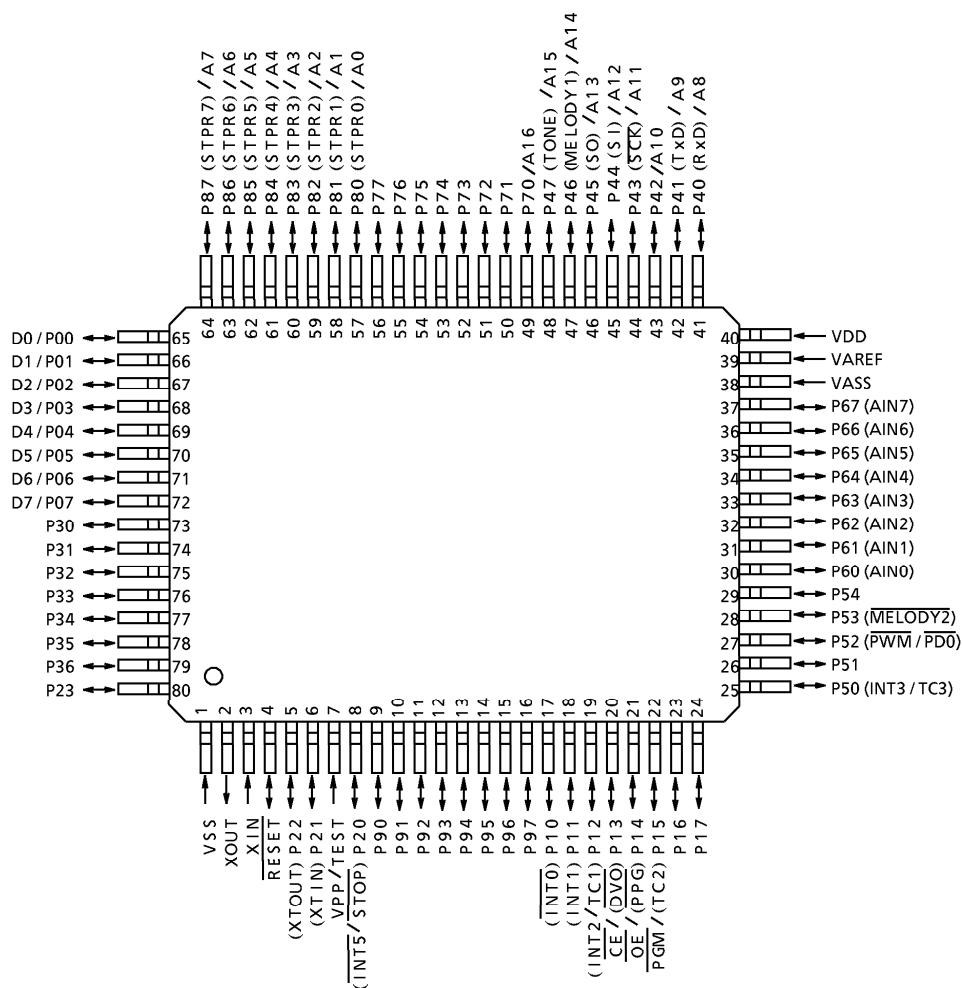


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## Pin Assignments (Top View)

P-QFP80-1420-0.80B



## Pin Function

The 87PM53 has two modes: MCU and PROM.

### (1) MCU mode

In this mode, the 87PM53 is pin compatible with the 87CM53 (fix the TEST pin at low level.)

### (2) PROM mode

| Pin Name (PROM mode)           | Input/Output | Functions                                                   | Pin Name (MCU mode) |
|--------------------------------|--------------|-------------------------------------------------------------|---------------------|
| A16                            | Input        | PROM address inputs                                         | P70                 |
| A15 to A8                      |              |                                                             | P47 to P40          |
| A7 to A0                       |              |                                                             | P87 to P80          |
| D7 to D0                       | I/O          | PROM data input/outputs                                     | P07 to P00          |
| $\overline{CE}$                | Input        | Chip enable signal input (active low)                       | P13                 |
| $\overline{OE}$                |              | Output enable signal input (active low)                     | P14                 |
| $\overline{PGM}$               |              | Program mode signal input                                   | P15                 |
| VPP                            | Power supply | + 12.75 V / 5 V (Program supply voltage)                    | TEST                |
| VCC                            |              | + 6.25 V / 5 V                                              | VDD                 |
| GND                            |              | 0 V                                                         | VSS                 |
| P36 to P30                     | I/O          | Pull-up with resistance for input processing.               |                     |
| P54 to P50                     |              |                                                             |                     |
| P67 to P60                     |              |                                                             |                     |
| P77 to P72                     |              |                                                             |                     |
| P11                            |              | PROM mode setting pin. Be fixed at high level.              |                     |
| P21                            |              |                                                             |                     |
| P71                            |              | PROM mode setting pin. Be fixed at low level.               |                     |
| P17, P16, P12, P10<br>P22, P20 |              |                                                             |                     |
| $\overline{RESET}$             |              |                                                             |                     |
| 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 87PM53 hardware configuration and operation. The configuration and functions of the 87PM53 are the same as those of the 87CM53, except in that a one-time PROM is used instead of an on-chip mask ROM.

The 87PM53 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 87PM53 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 87CM53 (the TEST / VPP pin cannot be used open because it has no built-in pull-down resistance).

##### 1.1.1 Program Memory

The 87PM53 has a 32K × 8-bit (addresses 8000<sub>H</sub>–FFFF<sub>H</sub> in the MCU mode, addresses 18000<sub>H</sub>–1FFFF<sub>H</sub> in the PROM mode) of program memory (OTP).

When the 87PM53 is used as a system evaluation of the 87CM53, the data is written to the program storage area shown in Figure 1-1.

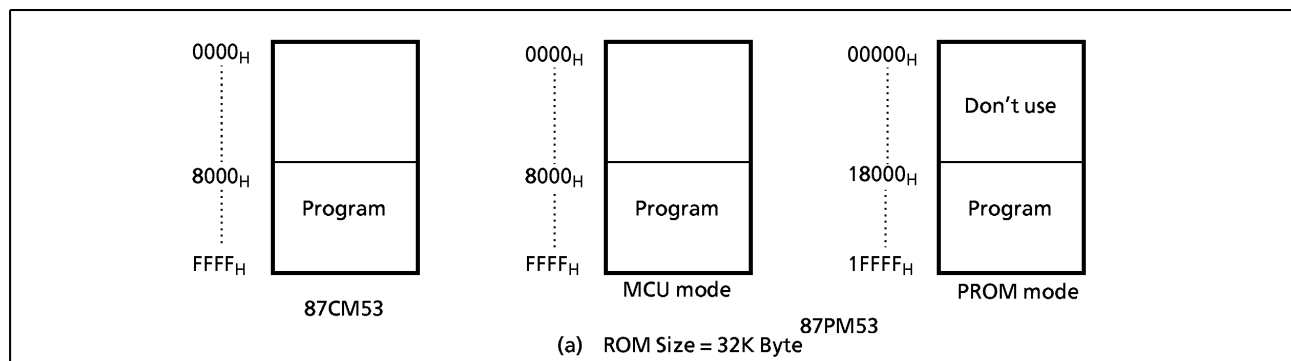


Figure 1.1 Program Memory Area

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

## Electrical Characteristics

(1) 87PM53

## 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    |
| 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, P8, P9 | 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, P8, P9 | 160                            | 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 60                     | °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 60°C)

| Parameter          | Symbol           | Pins                    | Conditions                     |                        | Min                    | Max                    | Unit |
|--------------------|------------------|-------------------------|--------------------------------|------------------------|------------------------|------------------------|------|
| Supply Voltage     | V <sub>DD</sub>  |                         | f <sub>c</sub> = 8 MHz         | NORMAL1, 2 mode        | 4.5                    | 5.5                    | V    |
|                    |                  |                         |                                | IDLE1, 2 mode          |                        |                        |      |
|                    |                  |                         | f <sub>c</sub> ≤ 4.2 MHz       | NORMAL1, 2 mode        | 2.2<br>Note 2          |                        |      |
|                    |                  |                         |                                | IDLE1, 2 mode          |                        |                        |      |
|                    |                  |                         | f <sub>s</sub> =<br>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    | f <sub>c</sub>   | XIN, XOUT               | V <sub>DD</sub> = 4.5 to 5.5 V |                        | 3.58                   | 8.0                    | MHz  |
|                    |                  |                         | V <sub>DD</sub> = 2.2 to 5.5 V |                        |                        | 4.19                   |      |
|                    | f <sub>s</sub>   | 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: The supply voltage range of the conditions shows the value in NORMAL1, 2 modes and IDLE1, 2 modes.

**Note 3:** When the A/D converter is used, V<sub>DD</sub> must be set to ≥ 2.7 V.

## D.C. Characteristics

(V<sub>SS</sub> = 0 V, T<sub>opr</sub> = – 30 to 60°C)

| Parameter                          | Symbol           | Pins                                                                     | Conditions                                                                             |                                 | Min                                                                                      | Typ.           | Max  | Unit |     |
|------------------------------------|------------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------------------------|------------------------------------------------------------------------------------------|----------------|------|------|-----|
| Hysteresis Voltage                 | V <sub>HS</sub>  | Hysteresis input                                                         |                                                                                        |                                 | –                                                                                        | 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> | Sink open drain port and tri-state port                                  |                                                                                        |                                 |                                                                                          |                |      |      |     |
|                                    | I <sub>IN3</sub> | RESET, STOP                                                              |                                                                                        |                                 |                                                                                          |                |      |      |     |
| Input Resistance                   | R <sub>IN2</sub> | RESET                                                                    |                                                                                        |                                 | 100                                                                                      | 220            | 450  | kΩ   |     |
|                                    | R <sub>IN</sub>  | P8 pull-up resistor                                                      |                                                                                        |                                 | 30                                                                                       | 70             | 150  |      |     |
| Output Leakage Current             | I <sub>LO</sub>  | Sink open drain port                                                     | V <sub>DD</sub> = 5.5V, V <sub>OUT</sub> = 5.5V                                        |                                 | –                                                                                        | –              | 2    | μA   |     |
| Output High Voltage                | V <sub>OH2</sub> | Try-state port                                                           | 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 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>V <sub>IN</sub> = 5.3V/0.2V<br>fc = 8 MHz<br>fs = 32.768 kHz | TONE no output                  | –                                                                                        | 9              | 12   | mA   |     |
| Supply Currnt in IDLE 1, 2 mode    |                  |                                                                          |                                                                                        | TONE output                     | –                                                                                        | 10.5           | 13.5 |      |     |
|                                    |                  |                                                                          |                                                                                        | TONE no output                  | –                                                                                        | 4.5            | 6.5  |      |     |
| Supply Currnt in NORMAL 1, 2 mode  |                  |                                                                          |                                                                                        | TONE output                     | –                                                                                        | 6.0            | 8.0  |      |     |
|                                    |                  |                                                                          |                                                                                        | Supply Currnt in IDLE 1, 2 mode | V <sub>DD</sub> = 2.2V<br>V <sub>IN</sub> = 2.2V/0.2V<br>fc = 4.2 MHz<br>fs = 32.768 kHz | TONE no output | –    |      | 1.5 |
| TONE output                        |                  |                                                                          |                                                                                        |                                 | –                                                                                        | 2.0            | 3.0  |      |     |
| Supply Current in SLOW mode        | I <sub>DD</sub>  | V <sub>DD</sub> = 3.0V<br>V <sub>IN</sub> = 2.8V/0.2V<br>fs = 32.768 kHz | TONE no output                                                                         | –                               | 0.8                                                                                      | 1.8            |      |      |     |
|                                    |                  |                                                                          | TONE output                                                                            | –                               | 1.3                                                                                      | 2.3            |      |      |     |
|                                    |                  |                                                                          |                                                                                        |                                 |                                                                                          |                |      |      |     |
| Supply Current in SLEEP mode       | I <sub>DD</sub>  |                                                                          | V <sub>DD</sub> = 5.5V<br>V <sub>IN</sub> = 5.3V/0.2V                                  | –                               | 30                                                                                       | 60             | μA   |      |     |
|                                    |                  |                                                                          |                                                                                        | –                               | 15                                                                                       | 30             | μA   |      |     |
| Supply Current in STOP mode        | I <sub>DD</sub>  |                                                                          | V <sub>DD</sub> = 5.5V<br>V <sub>IN</sub> = 5.3V/0.2V                                  |                                 | 0.5                                                                                      | 10             | μA   |      |     |

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

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

## A/D Conversion Characteristics

(V<sub>SS</sub> = 0V, V<sub>DD</sub> = 2.7 to 5.5V, Topr = – 30 to 60°C)

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

Note: Total Error = total number of each type error excluding quantization error.

## Tone Output Characteristics

(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 2.2 to 5.5 V, Topr = – 30 to 60°C)

| Parameter                          | Symbol            | Conditions                                                                        | Min | Typ. | Max  | Unit  |
|------------------------------------|-------------------|-----------------------------------------------------------------------------------|-----|------|------|-------|
| Tone Output Voltage (ROW)          | V <sub>TONE</sub> | R <sub>L</sub> ≥ 10 kΩ, V <sub>DD</sub> = 2.2 V                                   | 126 | 150  | 178  | mVrms |
| Pre-Emphasis High Band (COL / ROW) | PEHB              | PEHB = 20 log (COL / ROW)                                                         | 1   | 2    | 3    | dB    |
| Output Distortion                  | DIS               |                                                                                   | —   | —    | 5    | %     |
| Frequency Stability                | Δf                | f <sub>c</sub> = 3.84 MHz, 4.00 MHz, 8.00 MHz<br>(Except error of osc. frequency) | —   | —    | 0.70 | %     |
|                                    |                   | f <sub>c</sub> = 3.58 MHz<br>(Except error of osc. frequency)                     | —   | —    | 0.66 |       |
|                                    |                   | f <sub>c</sub> = 4.19 MHz<br>(Except error of osc. frequency)                     | —   | —    | 0.93 |       |

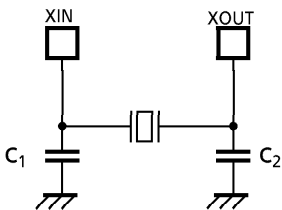
A.C. Characteristics

(V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 4.5 to 5.5 V, T<sub>opr</sub> = – 30 to 60°C)

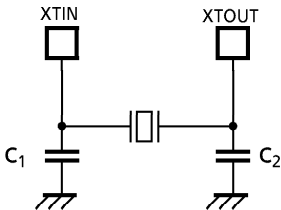
| Parameter                    | Symbol | Conditions                                                   | Min       | Typ. | Max       | Unit |
|------------------------------|--------|--------------------------------------------------------------|-----------|------|-----------|------|
| Machine Cycle Time           | tcy    | In NORMAL1, 2 mode (gear ratio)                              | 0.5 (1/1) | —    | 8.9 (1/8) | μs   |
|                              |        | In IDLE1, 2 mode (gear ratio)                                |           |      |           |      |
|                              |        | In SLOW mode                                                 | 117.6     |      | 133.3     |      |
|                              |        | In SLEEP mode                                                |           |      |           |      |
| High Level Clock Pulse Width | tWCH   | For external clock operation (XIN input)<br>fc = 8 MHz       | 50        | —    | —         | ns   |
| Low Level Clock Pulse Width  | tWCL   |                                                              |           |      |           |      |
| High Level Clock Pulse Width | tWSH   | For external clock operation (XTIN input)<br>fs = 32.768 kHz | 14.7      | —    | —         | μs   |
| Low Level Clock Pulse Width  | tWSL   |                                                              |           |      |           |      |

Recommended Oscillating Condition

| Parameter      | Oscillator         | Frequency  | Recommended Oscillator | Recommended Condition |                |
|----------------|--------------------|------------|------------------------|-----------------------|----------------|
|                |                    |            |                        | C <sub>1</sub>        | C <sub>2</sub> |
| High-frequency | 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  | Crystal Oscillator | 32.768 kHz | NDK    MX-38T          | 15 pF                 | 15 pF          |



(1) High-frequency



(2) Low-frequency

**Note:** When it is used in high electrical field, an electrical shield of the package is recommended to retain normal operations

**Note:** To obtain an accurate oscillating frequency the condenser capacity must be adjusted on the sct.



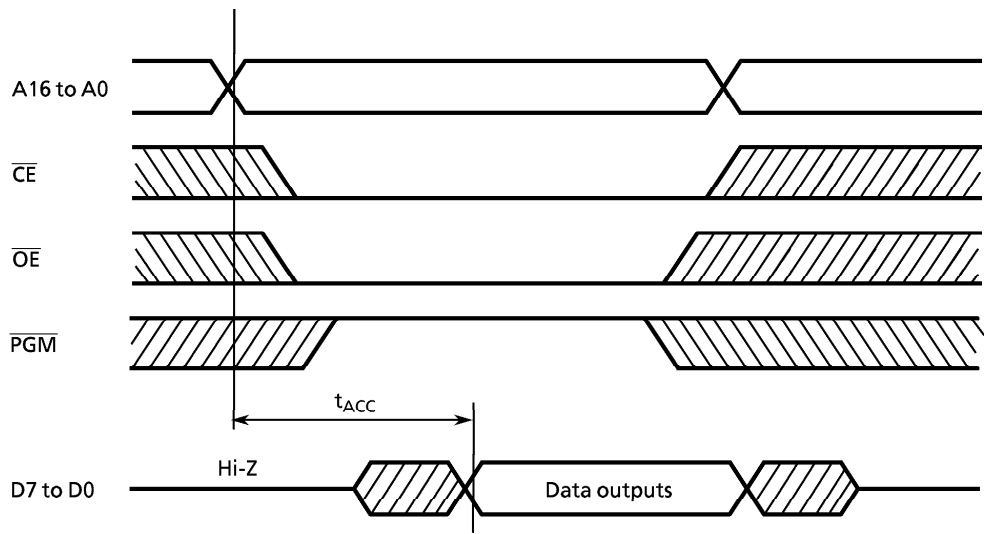
D.C./A.C. Characteristics (PROM mode)

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

(1) Read Operation

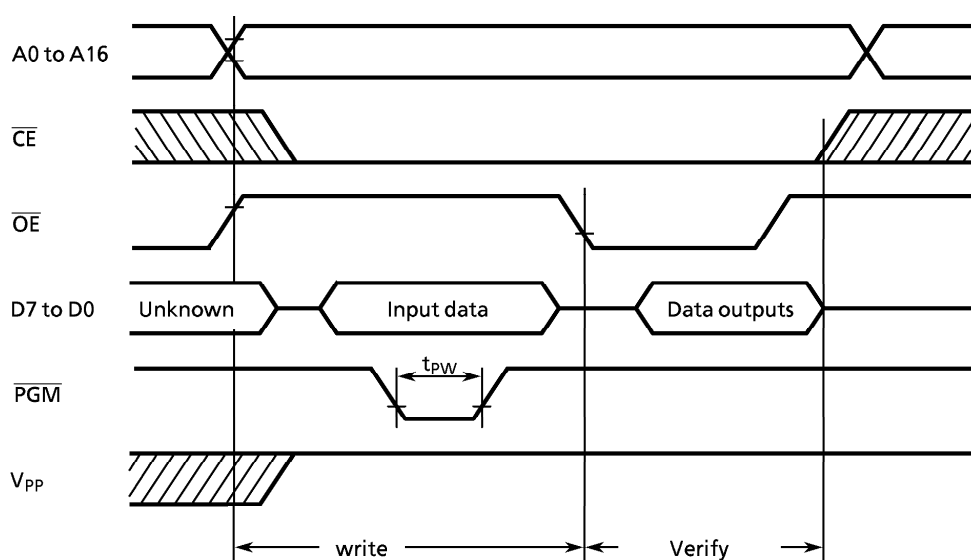
| Parameter                    | Symbol           | Conditions                     | Min  | Typ.                       | Max             | Unit |
|------------------------------|------------------|--------------------------------|------|----------------------------|-----------------|------|
| Input High Voltage           | V <sub>IH4</sub> |                                | 2.2  | —                          | V <sub>CC</sub> | V    |
| Input Low Voltage            | V <sub>IL4</sub> |                                | 0    | —                          | 0.8             | V    |
| Power Supply Voltage         | V <sub>CC</sub>  |                                | 4.75 | 5.0                        | 5.25            | V    |
| Program Power Supply Voltage | V <sub>PP</sub>  |                                |      |                            |                 |      |
| 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



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

| Parameter                    | Symbol    | Conditions              | Min   | Typ.  | Max      | Unit |
|------------------------------|-----------|-------------------------|-------|-------|----------|------|
| Input High Voltage           | $V_{IH4}$ |                         | 2.2   | –     | $V_{CC}$ | V    |
| Input Low Voltage            | $V_{IL4}$ |                         | 0     | –     | 0.8      | V    |
| Power Supply Voltage         | $V_{CC}$  |                         | 6.0   | 6.25  | 6.5      | V    |
| Program Power Supply Voltage | $V_{PP}$  |                         | 12.5  | 12.75 | 13.0     | V    |
| Initial Program Pulse Width  | $t_{PW}$  | $V_{CC} = 6.0\text{ V}$ | 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 increased.

**Note2:** The device must not be set to the EPROM programmer or picked up from it under applying the program voltage ( $12.5\text{ V} \pm 0.5\text{ V} = \text{V}$ ) 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.