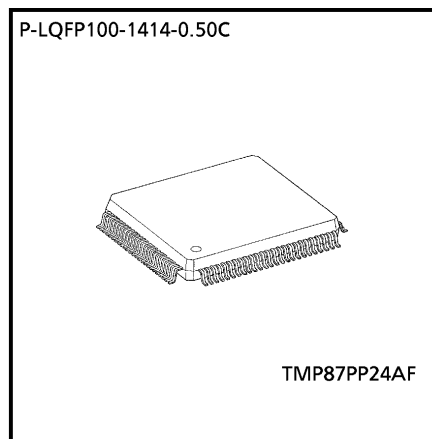


## CMOS 8-Bit Microcontroller

**TMP87PP24AF**

The TMP87PP24A is a One-Time PROM microcontroller with low-power 384 Kbits electrically programmable read only memory for the TMP87CM24A/CP24A system evaluation. The TMP87PP24A is pin compatible with the TMP87CM24A/CP24A. The operations possible with the TMP87CM24A/CP24A can be performed by writing programs to PROM. The TMP87PP24A can write and verify in the same way as the TMM571000D using an adaptor socket BM11127 and an EPROM programmer.

Product No.	OTP	RAM	Package	OTP Adapter
TMP87PP24AF	48 K × 8 bits	2 K × 8 bits	P-LQFP100-1414-0.50C	BM11127

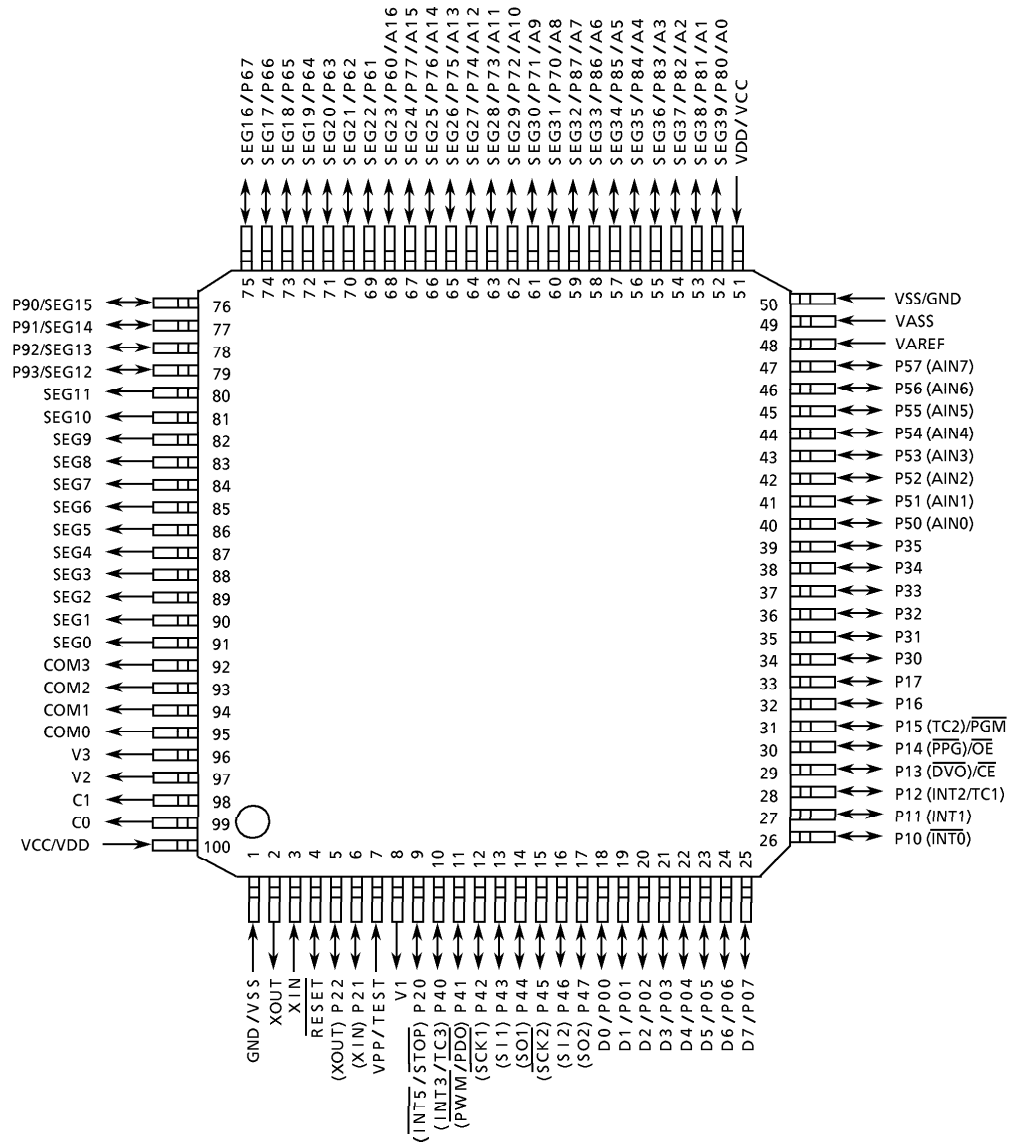


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Pin Assignments (Top View)

P-LQFP100-1414-0.50C



## Pin Function

The TMP87PP24A has two modes: MCU and PROM.

(1) MCU mode

In this mode, the TMP87PP24A is pin compatible with the TMP87CM24A/CP24A (fix the TEST pin at low level.)

(2) PROM mode

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

### Operational Description

The following explains the TMP87PP24A hardware configuration and operation. The configuration and functions of the TMP87PP24A are the same as those of the TMP87CM24A/CP24A, except in that a one-time PROM is used instead of an on-chip mask ROM.

The TMP87PP24A 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 TMP87PP24A 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 TMP87CM24A/CP24A (the TEST/VPP pin cannot be used open because it has no built-in pull-down resistance).

#### 1.1.1 Program Memory

The TMP87PP24A has a 48K × 8-bit (addresses 4000<sub>H</sub> to FFFF<sub>H</sub> in the MCU mode, addresses 14000<sub>H</sub> to 1FFFF<sub>H</sub> in the PROM mode) of program memory (OTP).

When the TMP87PP24A is used as a system evaluation of the TMP87CM24A/CP24A, the data is written to the program storage area show in Figure 1-1.

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

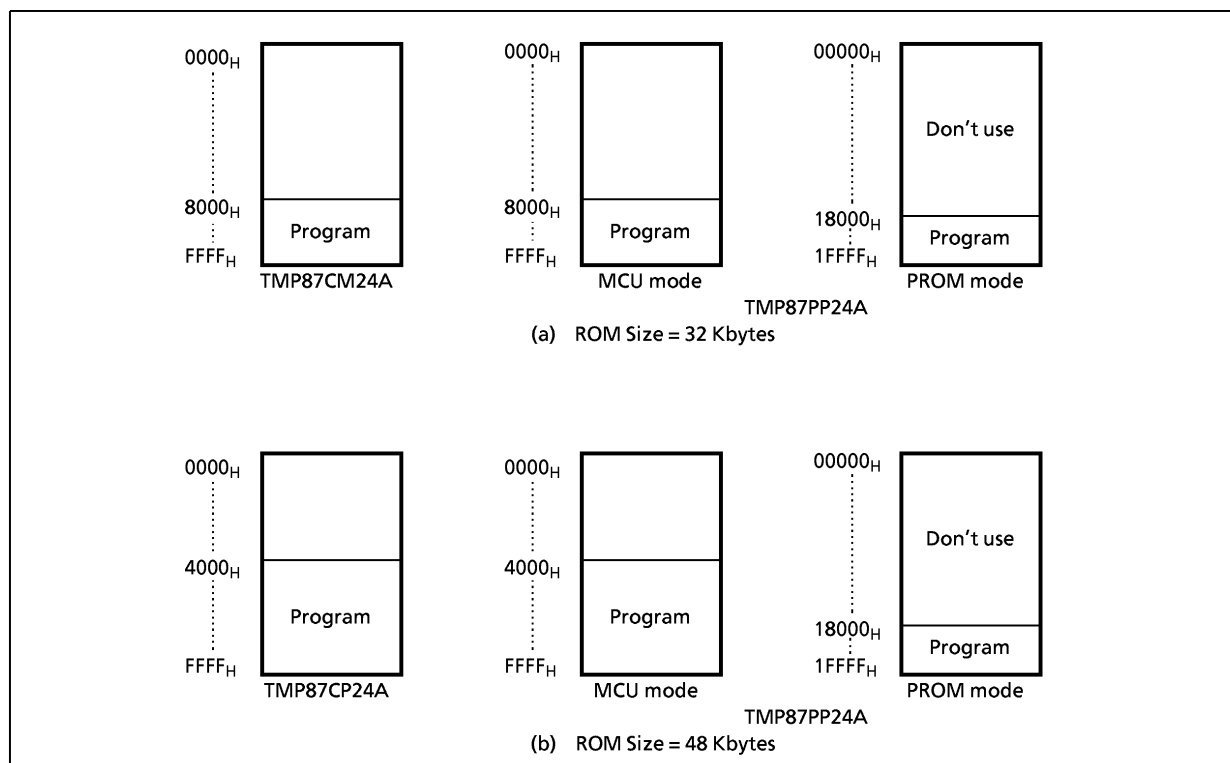


Figure 1-1. Program Memory Area

## Electrical Characteristics

## Absolute Maximum Ratings

 $(V_{SS} = 0\text{ V})$ 

Parameter	Symbol	Pins	Ratings	Unit
Supply Voltage	$V_{DD}$		- 0.3 to 6.5	V
Program Voltage	$V_{PP}$	TEST/ $V_{PP}$	- 0.3 to 13.0	
Input Voltage	$V_{IN}$		- 0.3 to $V_{DD} + 0.3$	
Output Voltage	$V_{OUT1}$	Except P20 and P3 ports	- 0.3 to $V_{DD} + 0.3$	mV
	$V_{OUT2}$	Ports P20, P3	- 0.3 to 5.5	
Output Current (Per 1 pin)	$I_{OUT1}$	Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41)	3.2	mA
	$I_{OUT2}$	P41	30	
Output Current (Total)	$\Sigma I_{OUT1}$	Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41)	120	
	$\Sigma I_{OUT2}$	P41	30	
Power Dissipation [ $T_{opr} = 70^{\circ}\text{C}$ ]	PD		350	mW
Soldering Temperature (time)	$T_{sld}$		260 (10 s)	$^{\circ}\text{C}$
Storage Temperature	$T_{stg}$		- 55 to 125	
Operating Temperature	$T_{opr}$		- 10 to 70	

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

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

Parameter	Symbol	Pins	Conditions	Min	Max	Unit
Supply Voltage	$V_{DD}$		$f_c = 8\text{ MHz}$	NORMAL1, 2 mode	4.5	5.5
				IDLE1, 2 mode		
			$f_c = 4.2\text{ MHz}$	NORMAL1, 2 mode	2.2	
				IDLE1, 2 mode		
			$f_s = 32.768\text{ kHz}$	SLOW mode	2.0	
SLEEP mode						
	STOP mode					
Input High Voltage	$V_{IH1}$	Except hysteresis input	$V_{DD} \geq 4.5\text{ V}$	$V_{DD} \times 0.70$	$V_{DD}$	V
	$V_{IH2}$	Hysteresis input		$V_{DD} \times 0.75$		
	$V_{IH3}$			$V_{DD} < 4.5\text{ V}$		
Input Low Voltage	$V_{IL1}$	Except hysteresis input	$V_{DD} \geq 4.5\text{ V}$	0	$V_{DD} \times 0.30$	
	$V_{IL2}$	Hysteresis input		$V_{DD} \times 0.25$		
	$V_{IL3}$			$V_{DD} < 4.5\text{ V}$	$V_{DD} \times 0.10$	
Clock Frequency	$f_c$	XIN, XOUT	$V_{DD} = 4.5\text{ to }5.5\text{ V}$	0.4	8.0	MHz
			$V_{DD} = 2.2\text{ to }5.5\text{ V}$		4.2	
	$f_s$	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  $f_c$ : Supply voltage range is specified in NORMAL1/2 mode and IDLE1/2 mode.

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

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.  
Note 3: I<sub>DD</sub> ; Except for I<sub>REF</sub>  
Note 4: V<sub>LCD2</sub> indicates an output voltage at the 2/3 level when operating in the 1/4 or 1/3 duty mode.  
Note 5: V<sub>LCD1</sub> indicates an output voltage at the 1/3 level when operating in the 1/4 or 1/3 duty mode.

## AD Conversion Characteristics (I)

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

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Analog Reference Voltage	$V_{AREF}$		2.7	–	$V_{DD}$	V
	$V_{ASS}$		$V_{SS}$	–	1.5	
Analog Input Voltage	$V_{AIN}$		$V_{ASS}$	–	$V_{AREF}$	
Analog Supply Current	$I_{REF}$	$V_{AREF} = 5.5\text{ V}, V_{ASS} = 0.0\text{ V}$	–	0.5	1.0	mA
Nonlinearity Error		$V_{DD} = 5.0\text{ V}, V_{SS} = 0.0\text{ V}$ $V_{AREF} = 5.000\text{ V}$ $V_{ASS} = 0.000\text{ V}$ or $V_{DD} = 2.7\text{ V}, V_{SS} = 0.0\text{ V}$ $V_{AREF} = 2.700\text{ V}$ $V_{ASS} = 0.000\text{ V}$	–	–	$\pm 1$	LSB
Zero Point Error			–	–	$\pm 1$	
Full Scale Error			–	–	$\pm 1$	
Total Error			–	–	$\pm 2$	

Note: Quantizing error is not contained in those errors.

## AD Conversion Characteristics (II)

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

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Analog Reference Voltage	$V_{AREF}$		2.2	–	$V_{DD}$	V
	$V_{ASS}$		$V_{SS}$	–	–	
Analog Reference Voltage Range	$\Delta V_{AREF}$		2.2	–	–	
Analog Input Voltage	$V_{AIN}$		$V_{ASS}$	–	$V_{AREF}$	
Analog Supply Current	$I_{REF}$	$V_{AREF} = 5.5\text{ V}, V_{ASS} = 0.0\text{ V}$	–	0.5	1.0	mA
Nonlinearity Error		$V_{DD} = 2.2\text{ V}, V_{SS} = 0.0\text{ V}$ $V_{AREF} = 2.200\text{ V}$ $V_{ASS} = 0.000\text{ V}$	–	–	$\pm 2$	LSB
Zero Point Error			–	–	$\pm 2$	
Full Scale Error			–	–	$\pm 2$	
Total Error			–	–	$\pm 4$	

Note: Quantizing error is not contained in those errors.

## AC Characteristics ( I )

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

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	$t_{cy}$	In NORMAL 1, 2 mode	0.95	—	10	$\mu s$
		In IDLE 1, 2 mode				
		In SLOW mode	117.6	—	133.3	
		In SLEEP mode				
High Level Clock Pulse Width	$t_{WCH}$	For external clock operation (XIN input), $f_c = 8 \text{ MHz}$	50	—	—	ns
Low Level Clock Pulse Width	$t_{WCL}$					
High Level Clock Pulse Width	$t_{WSH}$	For external clock operation (XTIN input), $f_s = 32.768 \text{ kHz}$	14.7	—	—	$\mu s$
Low Level Clock Pulse Width	$t_{WSL}$					

## AC Characteristics ( II )

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

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

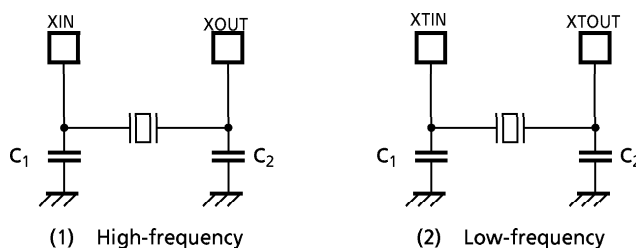


Recommended Oscillating Condition ( I ) (V<sub>SS</sub> = 0 V, V<sub>DD</sub> = 4.5 to 5.5 V, Topr = - 10 to 70°C)

Parameter	Osillator	Frequency	Recommender Oscillator		Recommended Condition	
					C <sub>1</sub>	C <sub>2</sub>
High-frequency	Ceramic Resonator	8 MHz	KYOCERA	KBR8.0M	30pF	30pF
			Standard/Lead Type (MURATA)	CSA8.00MTZ CST8.00MTW	built-in 30pF	built-in 30pF
			Standard/SMP Type (MURATA)	CSAC8.00MT	30pF	30pF
			Standard/Small ChipType (MURATA)	CSTC8.00MT	built-in 30pF	built-in 30pF
	Crystal Oscillator	8 MHz	TOYOCOM	210B 8.0000	20pF	20pF
			TOYOCOM	204B 4.0000		
Low-frequency	Crystal Oscillator	32.768 kHz	NDK	MX-38T	15pF	15pF

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

Parameter	Osillator	Frequency	Recommender Oscillator		Recommended Condition	
					C <sub>1</sub>	C <sub>2</sub>
High-frequency	Ceramic Resonator	4 MHz	Standard/Lead Type (MURATA)	CSA4.00MG CST4.00MGW	30pF built-in 30pF	30pF built-in 30pF
			Standard/SMD Type (MURATA)	CSA4.00MGC CSAC4.00MGCM CSTC4.00MG	30pF built-in 30pF	30pF built-in 30pF
			Standard/Small Chip Type	CSTCS4.00MG	built-in 10pF	built-in 10pF



Note1: When used in high electric field such as a picture tube, the package is recommended to be electrically shielded to maintain a regular operation.

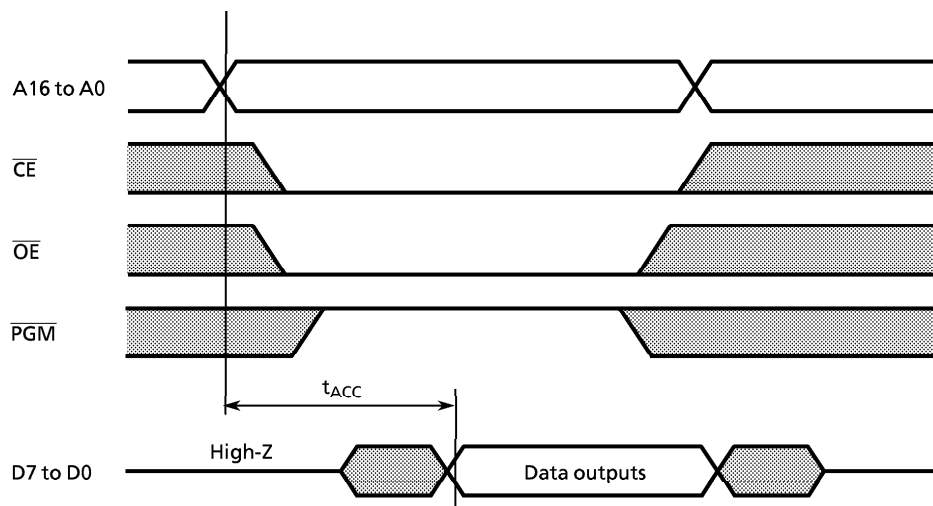
Note2: The product numbers and specifications of the resonators by Murata Manufacturing Co., Ltd. are subject to change. For up-to-date information, please refer to the following URL; <http://www.murata.co.jp/search/index.html>

DC/AC Characteristics (PROM mode) ( $V_{SS} = 0\text{ V}$ )

(1) Read Operation

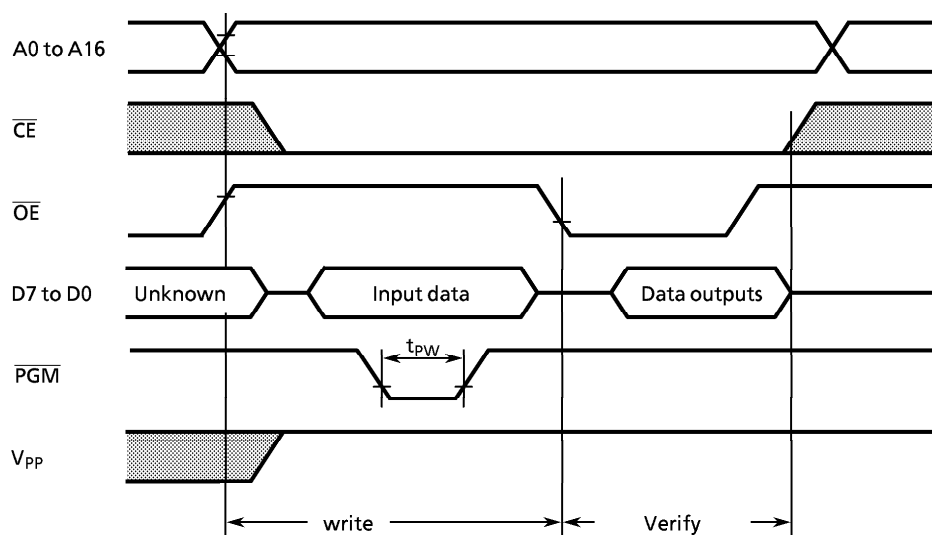
Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Input High Voltage	$V_{IH4}$		$V_{CC} \times 0.7$	—	$V_{CC}$	V
Input Low Voltage	$V_{IL4}$		0	—	$V_{CC} \times 0.12$	
Power Supply Voltage	$V_{CC}$		4.75	5.0	5.25	
Program Power Supply Voltage	$V_{PP}$					
Address Access Time	$t_{ACC}$	$V_{CC} = 5.0 \pm 0.25\text{ V}$	—	$1.5t_{cyc} + 300$	—	ns

Note:  $t_{cyc} = 500\text{ ns}$  at 8 MHz



(2) High-Speed Programming Operation (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	-	$V_{CC} \times 0.12$	
Power Supply Voltage	$V_{CC}$		6.0	6.25	6.5	
Program Power Supply Voltage	$V_{PP}$		12.5	12.75	13.0	
Initial Program Pulse Width	$t_{PW}$	$V_{CC} = 6.0\text{ V}$	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 increased.
- Note 2:** The device must not be set to the EPROM programmer or picked up from it under applying the program voltage ( $12.5\text{ V} \pm 0.5\text{ V} = V$ ) 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.

