

TOSHIBA

TOSHIBA Original CMOS 8-Bit Microcontroller

TLCS-870 Series

TMP87PM53FG

TOSHIBA CORPORATION

Semiconductor Company

Document Change Notification

The purpose of this notification is to inform customers about the launch of the Pb-free version of the device. The introduction of a Pb-free replacement affects the datasheet. Please understand that this notification is intended as a temporary substitute for a revision of the datasheet.

Changes to the datasheet may include the following, though not all of them may apply to this particular device.

1. Part number

Example: TMPxxxxxF TMPxxxxxFG

All references to the previous part number were left unchanged in body text. The new part number is indicated on the prelims pages (cover page and this notification).

2. Package code and package dimensions

Example: LQFP100-P-1414-0.50C LQFP100-P-1414-0.50F

All references to the previous package code and package dimensions were left unchanged in body text. The new ones are indicated on the prelims pages.

3. Addition of notes on lead solderability

Now that the device is Pb-free, notes on lead solderability have been added.

4. RESTRICTIONS ON PRODUCT USE

The previous (obsolete) provision might be left unchanged on page 1 of body text. A new replacement is included on the next page.

5. Publication date of the datasheet

The publication date at the lower right corner of the prelims pages applies to the new device.

1. Part number
2. Package code and dimensions

Previous Part Number (in Body Text)	Previous Package Code (in Body Text)	New Part Number	New Package Code	OTP
TMP87PM53F	QFP80-P-1420-0.80B	TMP87PM53FG	QFP80-P-1420-0.80B	—

*: For the dimensions of the new package, see the attached Package Dimensions diagram.

3. Addition of notes on lead solderability

The following solderability test is conducted on the new device.

Lead solderability of Pb-free devices (with the G suffix)

Test	Test Conditions	Remark
Solderability	(1) Use of Lead (Pb) -solder bath temperature = 230°C -dipping time = 5 seconds -the number of times = once -use of R-type flux (2) Use of Lead (Pb)-Free -solder bath temperature = 245°C -dipping time = 5 seconds -the number of times = once -use of R-type flux	Leads with over 95% solder coverage till lead forming are acceptable.

4. RESTRICTIONS ON PRODUCT USE

The following replaces the “RESTRICTIONS ON PRODUCT USE” on page 1 of body text.

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20070701-EN

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- For a discussion of how the reliability of microcontrollers can be predicted, please refer to Section 1.3 of the chapter entitled Quality and Reliability Assurance/Handling Precautions.

5. Publication date of the datasheet

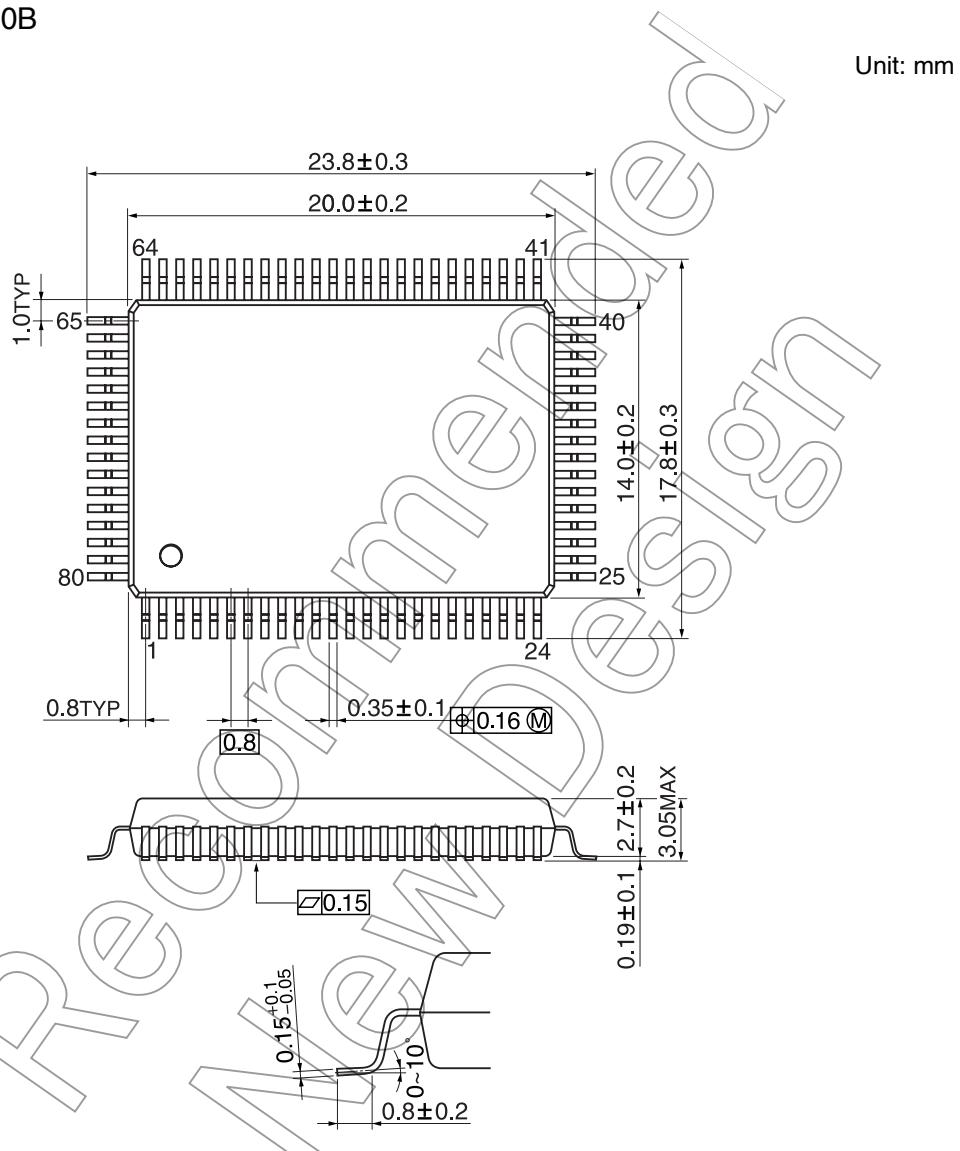
The publication date of this datasheet is printed at the lower right corner of this notification.

(Annex)

Package Dimensions

QFP80-P-1420-0.80B

Unit: mm

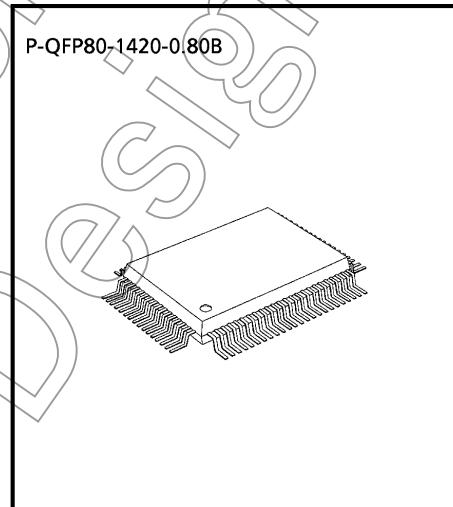


CMOS 8-Bit Microcontroller

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 x 8-bit	1 K x 8-bit	P-QFP80-1420-0.80B	BM11104

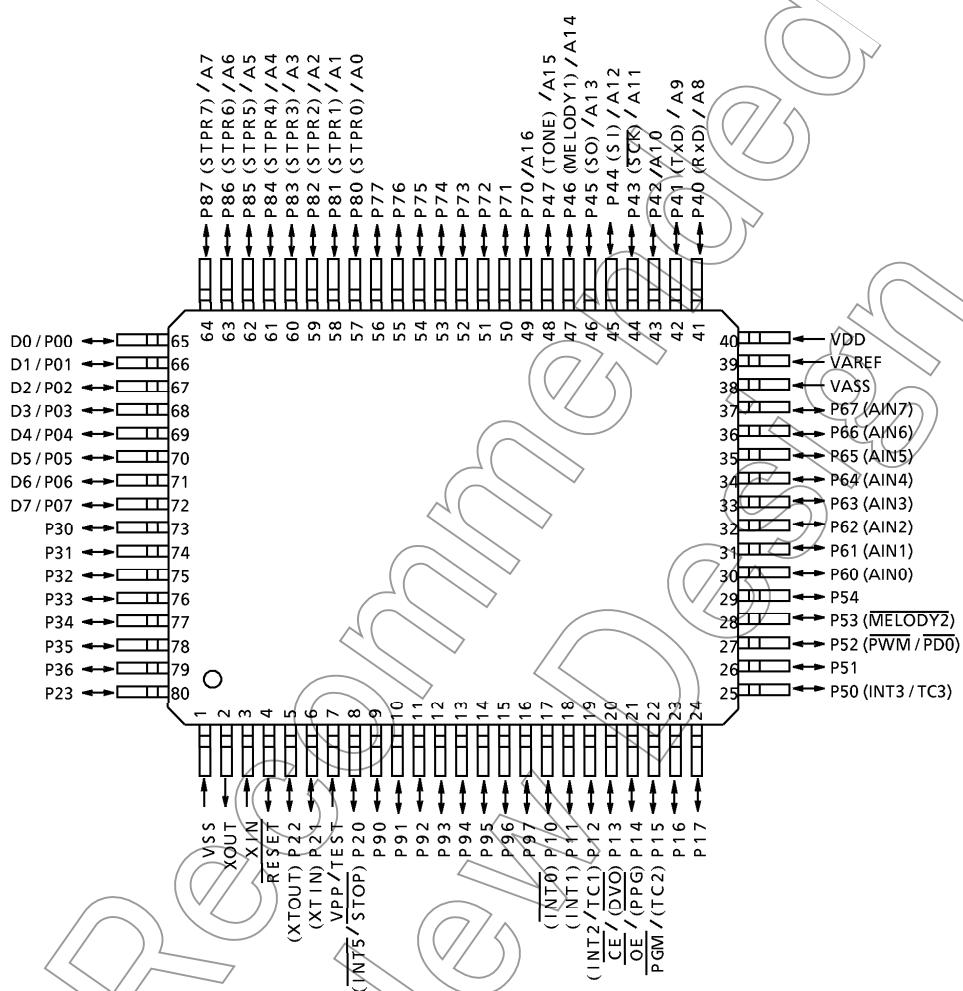


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Pin Assignments (Top View)

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			P70
A15 to A8	Input	PROM address inputs	P47 to P40
A7 to A0			P87 to P80
D7 to D0	I/O	PROM data input/outputs	P07 to P00
<u>CE</u>		Chip enable signal input (active low)	P13
<u>OE</u>	Input	Output enable signal input (active low)	P14
<u>PGM</u>		Program mode signal input	P15
VPP		+ 12.75 V / 5 V (Program supply voltage)	TEST
VCC	Power supply	+ 6.25 V / 5 V	VDD
GND		0 V	VSS
P36 to P30			
P54 to P50			
P67 to P60			
P77 to P72			
P11			
P21			
P71			
P17, P16, P12, P10			
P22, P20			
<u>RESET</u>			
XIN	Input		
XOUT	Output	Connect an 8MHz oscillator to stabilize the internal state.	
VAREF			
VASS	Power supply	0 V (GND)	

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 $32\text{K} \times 8$ -bit (addresses $8000_{\text{H}}\text{-}FFFF_{\text{H}}$ in the MCU mode, addresses $18000_{\text{H}}\text{-}1FFFF_{\text{H}}$ 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.

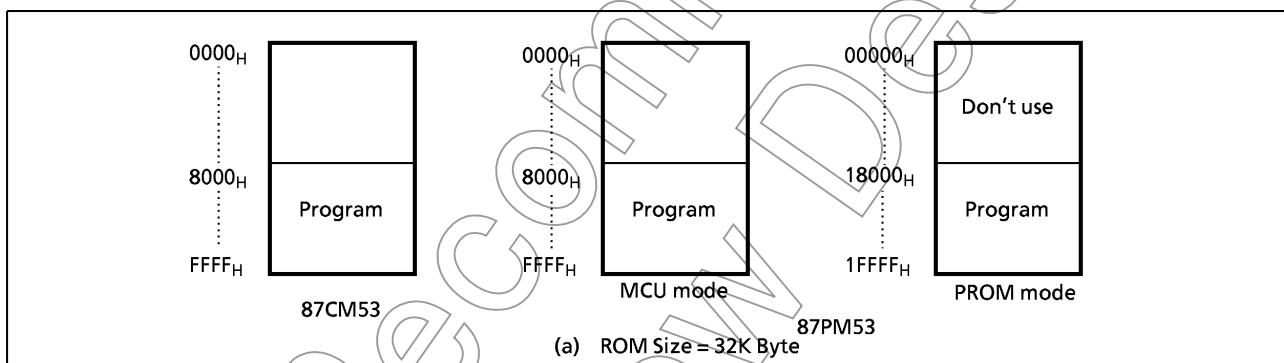


Figure 1.1 Program Memory Area

Note : Either write the data FF_{H} to the unused area or set the PROM programmer to access only the program storage area.

1.1.2 Data Memory

The 87PM53 has an on-chip 1K x 8-bit data memory (static RAM).

1.1.3 Input/Output Circuitry

(1) Control pins

The control pins of the 87PM53 are the same as those of the 87CM53 except that the TEST pin has no built-in pull-down resistance.

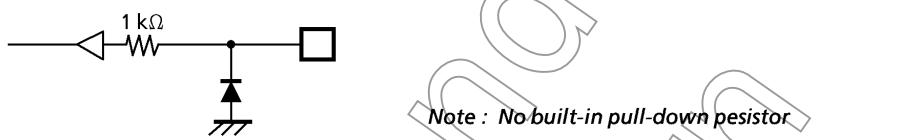


Figure 1-2. TEST pin

(2) I/O ports

The I/O circuits of 87PM53 I/O ports are the same as I/O circuitries of the 87CM53.

1.2 PROM Mode

The PROM mode is activated by setting the TEST, RESET pin and the ports P17 to P10, P22 to P20 and P71, as shown in Figure 1-3. The PROM mode is used to write and verify programs with a general-purpose PROM programmer.

Note : The high-speed programming mode can be used for program operation.

The 87PM53 is not supported an electric signature mode, so the ROM type must be set to TC571000D. (The settings may differ depending on the type of PROM programmer is use. Refer to the PROM programmer operation manual.

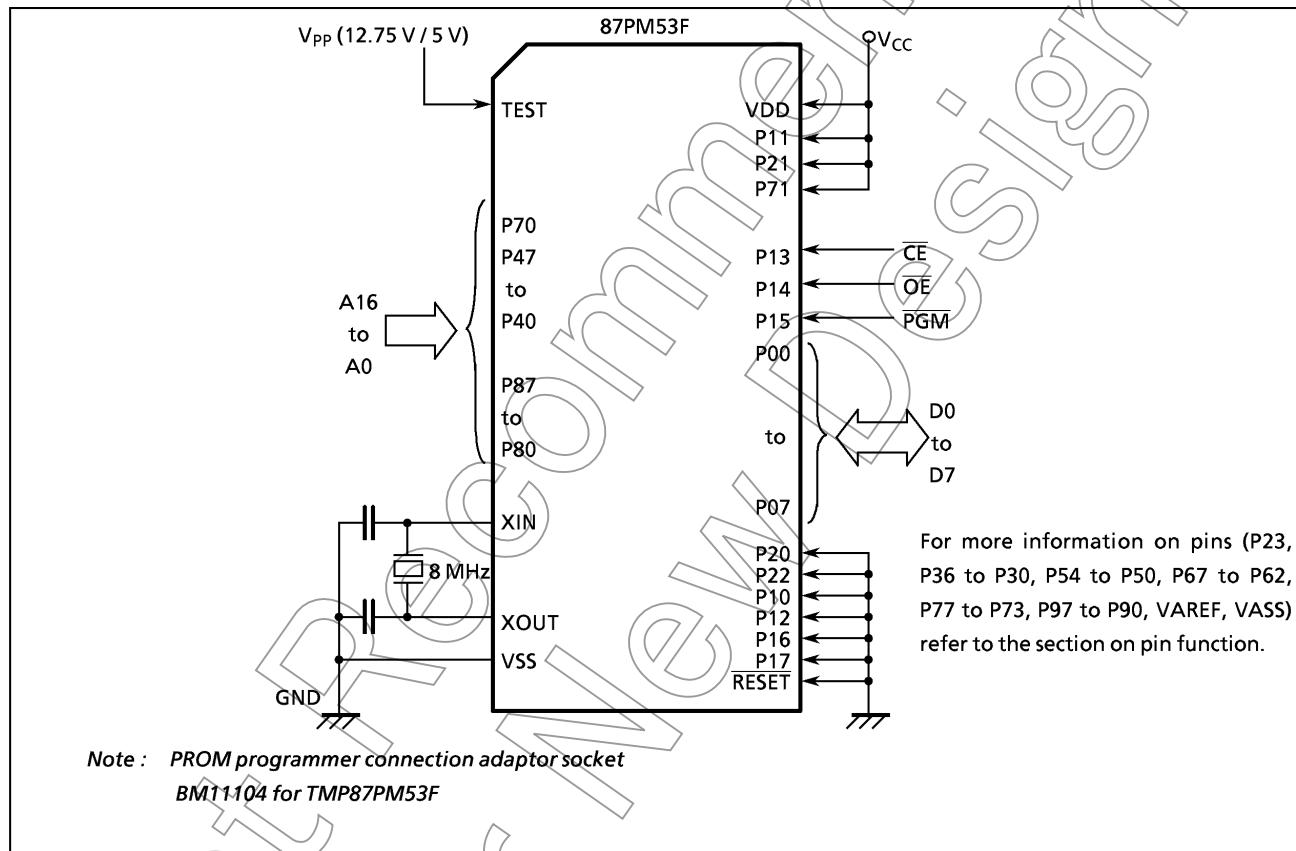


Figure 1-3. Setting for PROM Mode

1.2.1 Programming Flowchart (High-speed Programming Mode)

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 PGM input. The programmed data is verified. If incorrect, another 0.1 ms program pulse is applied. 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.

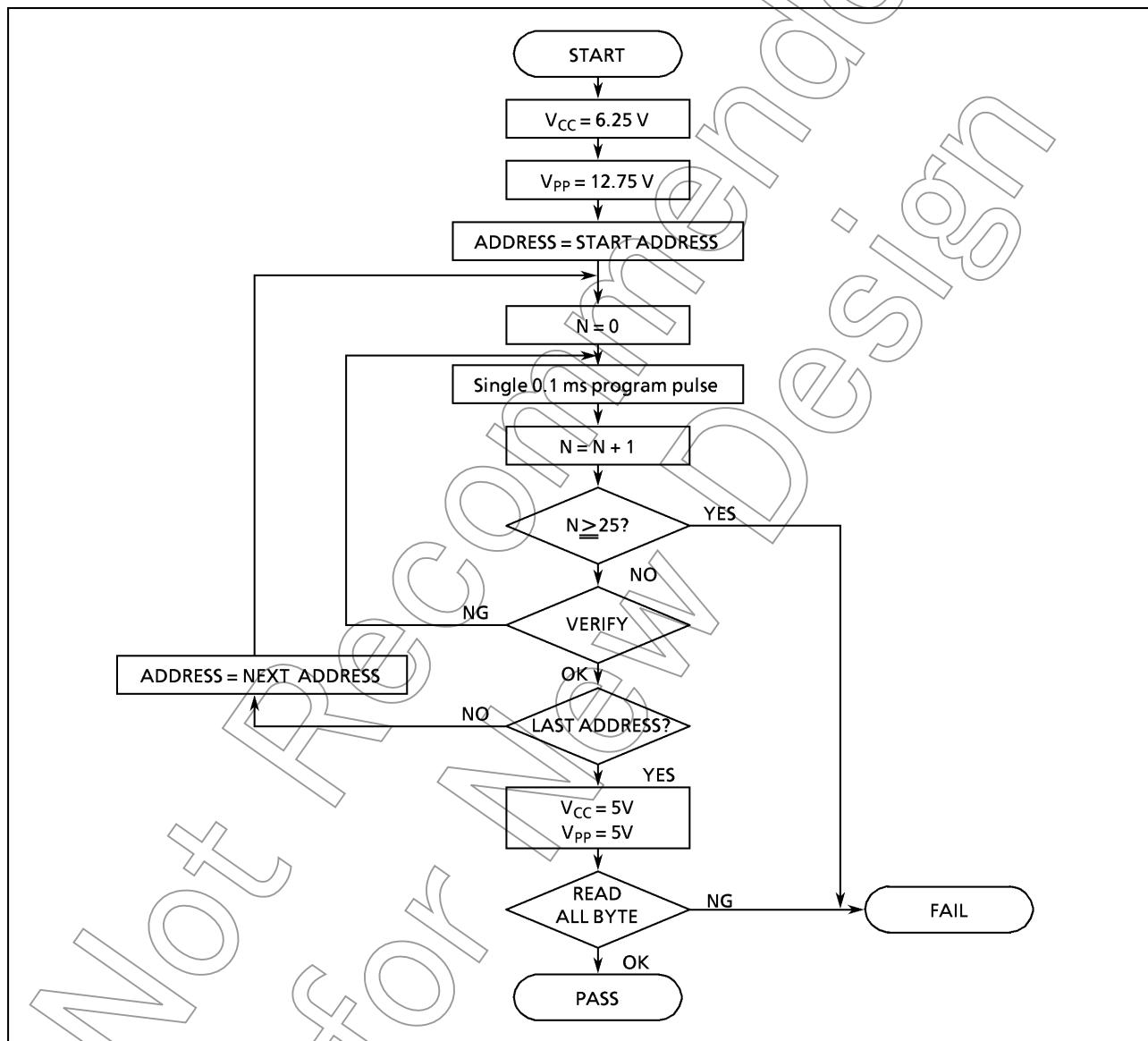


Figure 1-4. Flow Chart of High-speed Programming

1.2.2 Writing Method for General-purpose PROM Program

(1) Adapters
BM11104 : TMP87PM53F

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

(3) PROM programmer specifying
i) PROM type is specified to TC571000D.
Writing voltage: 12.75 V (high-speed program mode)

ii) Data transfer (copy) (note 1)
In the TMP87PM53, EPROM is within the addresses 18000_H to $1FFFF_H$. 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 08000_H to $0FFFF_H$ to addresses 18000 to $1FFFF_H$

iii) Writing address is specified. (note 1)
Start address : 18000_H
End address : $1FFFF_H$

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

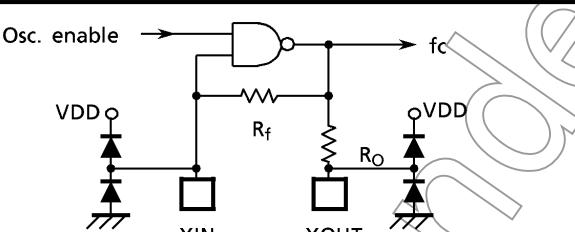
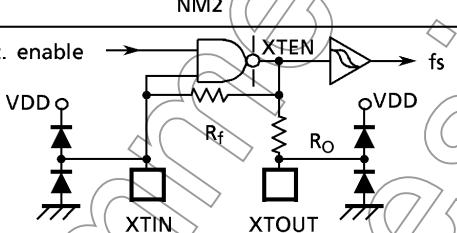
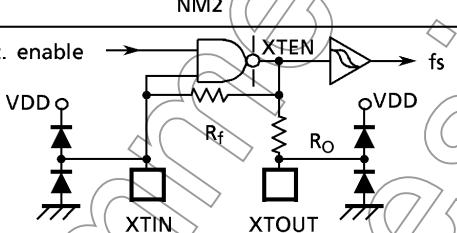
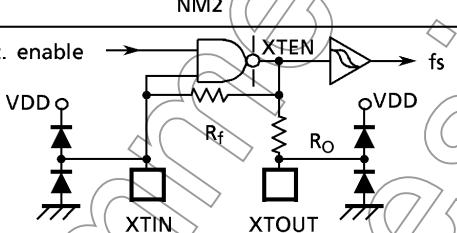
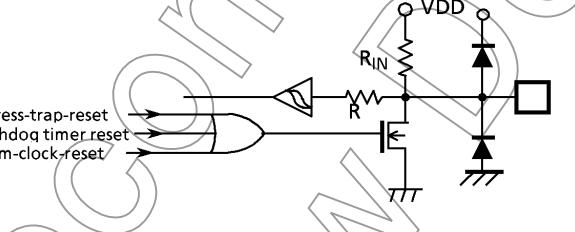
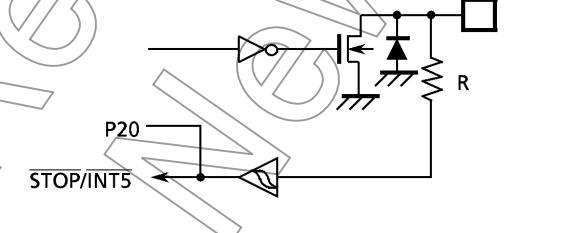
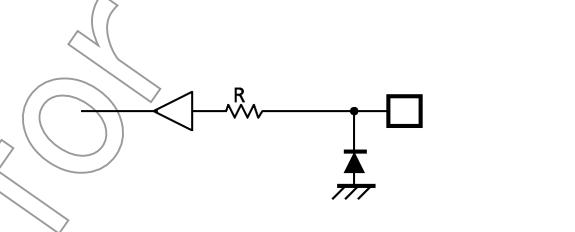
Note 2 : When MCU is set to an adapter or the adapter is set to PROM programmer, a position of pin 1 must be adjusted. If the setting is reversed, MCU, the adapter and PROM program is damaged.

Note 3 : The TMP87PM53 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.

INPUT / OUTPUT CIRCUITY

(1) Control pins

The input / output circuitries of the 87PM53 control pins are shown below.

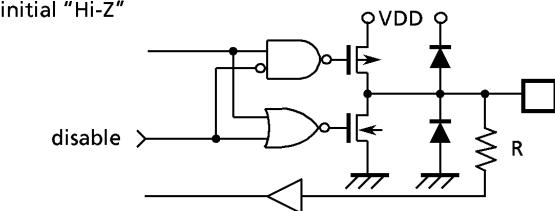
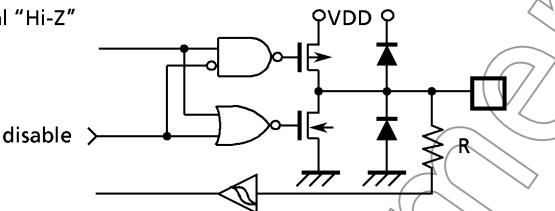
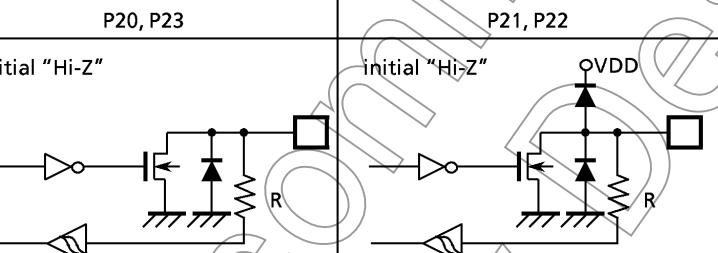
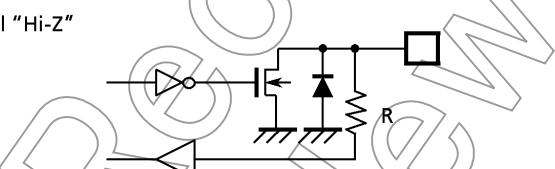
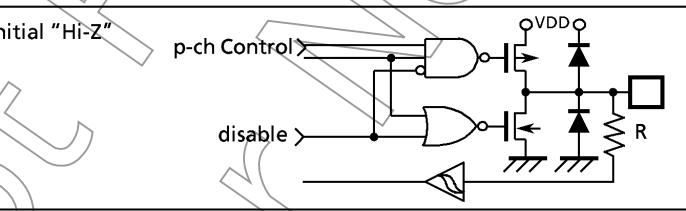
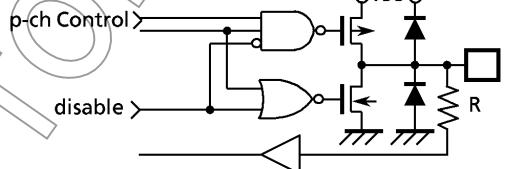
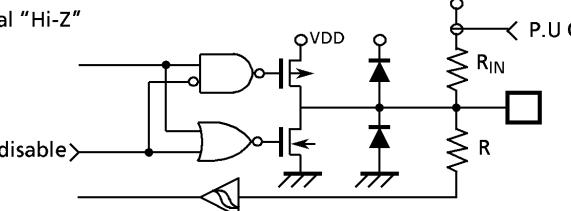
CONTROL PIN	I/O	INPUT / OUTPUT CIRCUITY and CODE		REMARKS				
XIN XOUT	Input Output			Resonator connecting pins (high-frequency) $R_f = 1.2 \text{ M}\Omega$ (typ.) $R_o = 1.5 \text{ k}\Omega$ (typ.)				
XTIN (P21) XTOUT (P22)	Input Output	<table border="1"> <tr> <td>NM1</td> <td>NM2</td> </tr> <tr> <td>Refer to port P2</td> <td>  </td></tr> </table>	NM1	NM2	Refer to port P2			Resonator connecting pins (low-frequency) $R_f = 6 \text{ M}\Omega$ (typ.) $R_o = 220 \text{ k}\Omega$ (typ.)
NM1	NM2							
Refer to port P2								
RESET	I/O			Sink open drain output Hysteresis input Pull-up resistor $R_{IN} = 220 \text{ k}\Omega$ (typ.) $R = 1 \text{ k}\Omega$ (typ.)				
STOP/INT5 (P20)	Input			Hysteresis input $R = 1 \text{ k}\Omega$ (typ.)				
TEST	Input			$R = 1 \text{ k}\Omega$ (typ.)				

Note1 : The TEST pin of the 87PM53 does not have a pull-down resistor. Be sure to fix the TEST pin to low in MCU mode.

Note2 : The 87PM53 is placed in the single-clock mode during reset. (NM1)

(2) Input/output ports

The input/output circuitries of the 87PM53 input/output ports are shown below.

PORT	I/O	INPUT/OUTPUT CIRCUITRY	REMARKS		
P0 P6	I/O	<p>initial "Hi-Z"</p>  <p>disable</p>	<p>Tri-state I/O</p> <p>$R = 1\text{k}\Omega$ (typ.)</p>		
P1	I/O	<p>initial "Hi-Z"</p>  <p>disable</p>	<p>Tri-state I/O</p> <p>Hysteresis input</p> <p>$R = 1\text{k}\Omega$ (typ.)</p>		
P2	I/O	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">P20, P23</td> <td style="width: 50%;">P21, P22</td> </tr> </table> <p>initial "Hi-Z"</p>  <p>disable</p>	P20, P23	P21, P22	<p>Sink open drain output</p> <p>Hysteresis input</p> <p>$R = 1\text{k}\Omega$ (typ.)</p>
P20, P23	P21, P22				
P3	I/O	<p>initial "Hi-Z"</p>  <p>disable</p>	<p>Sink open drain output</p> <p>High current output</p> <p>$R = 1\text{k}\Omega$ (typ.)</p>		
P4 P5	I/O	<p>initial "Hi-Z"</p>  <p>p-ch Control</p> <p>disable</p>	<p>Sink open drain or</p> <p>Tri-state I/O (Programmable port option)</p> <p>Hysteresis input</p> <p>$R = 1\text{k}\Omega$ (typ.)</p>		
P7 P9	I/O	<p>initial "Hi-Z"</p>  <p>p-ch Control</p> <p>disable</p>	<p>Sink open drain or</p> <p>Tri-state I/O (Programmable port option)</p> <p>$R = 1\text{k}\Omega$ (typ.)</p>		
P8	I/O	<p>initial "Hi-Z"</p>  <p>disable</p> <p>P.U Control</p> <p>$R_{IN} = 70\text{k}\Omega$ (typ.)</p> <p>$R = 1\text{k}\Omega$ (typ.)</p>	<p>Tri-state I/O</p> <p>Programmable</p> <p>Pull-up resistor</p> <p>$R_{IN} = 70\text{k}\Omega$ (typ.)</p> <p>$R = 1\text{k}\Omega$ (typ.)</p> <p>Hysteresis input</p>		

Electrical Characteristics

(1) 87PM53

Absolute Maximum Ratings

(V_{SS} = 0 V)

Parameter	Symbol	Conditions	Ratings	Unit
Supply Voltage	V _{DD}		- 0.3 to 6.5	V
Input Voltage	V _{IN}		- 0.3 to V _{DD} + 0.3	V
Output Voltage	V _{OUT}		- 0.3 to V _{DD} + 0.3	V
Output Current (Per 1pin)	I _{OUT1}	Ports P0, P1, P2, P4, P5, P6, P7, P8, P9	3.2	mA
	I _{OUT2}	Port P3	30	
Output Current (Total)	Σ I _{OUT1}	Ports P0, P1, P2, P4, P5, P6, P7, P8, P9	160	mA
	Σ I _{OUT2}	Port P3	120	
Power Dissipation [Topr = 70°C]	PD		350	mW
Soldering Temperature (time)	T _{sld}		260 (10 s)	°C
Storage Temperature	T _{stg}		- 55 to 125	°C
Operating Temperature	Topr		- 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_{SS} = 0 V, Topr = - 30 to 60°C)

Parameter	Symbol	Pins	Conditions	Min	Max	Unit	
Supply Voltage	V _{DD}		fc = 8 MHz	NORMAL1, 2 mode	4.5	V	
				IDLE1, 2 mode			
			fc ≤ 4.2 MHz	NORMAL1, 2 mode	2.2 Note 2		
				IDLE1, 2 mode			
			fs = 32.768 kHz	SLOW mode			
Input High Voltage	V _{IH1}	Except hysteresis input	V _{DD} ≥ 4.5 V	V _{DD} × 0.70	V _{DD}	V	
	V _{IH2}	Hysteresis input		V _{DD} × 0.75			
	V _{IH3}		V _{DD} < 4.5 V	V _{DD} × 0.90			
Input Low Voltage	V _{IL1}	Except hysteresis input	V _{DD} ≥ 4.5 V	V _{DD} × 0.30	0	V	
	V _{IL2}	Hysteresis input		V _{DD} × 0.25			
	V _{IL3}		V _{DD} < 4.5 V	V _{DD} × 0.10			
Clock Frequency	fc	XIN, XOUT	V _{DD} = 4.5 to 5.5 V	8.0	3.58	MHz	
			V _{DD} = 2.2 to 5.5 V	4.19			
	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: The supply voltage range of the conditions shows the value in NORMAL1, 2 modes and IDLE 1, 2 modes.

Note 3: When the A/D converter is used, V_{DD} must be set to ≥ 2.7 V.

D.C. Characteristics

(V_{SS} = 0 V, Topr = -30 to 60°C)

Parameter	Symbol	Pins	Conditions	Min	Typ.	Max	Unit		
Hysteresis Voltage	V _{HS}	Hysteresis input		-	0.9	-	V		
Input Current	I _{IN1}	TEST	V _{DD} = 5.5V V _{IN} = 5.5V / 0V	-	-	± 2	μA		
	I _{IN2}	Sink open drain port and tri-state port							
	I _{IN3}	RESET, STOP							
Input Resistance	R _{IN2}	RESET		100	220	450	kΩ		
	R _{IN}	P8 pull-up resistor		30	70	150			
Output Leakage Current	I _{LO}	Sink open drain port	V _{DD} = 5.5V, V _{OUT} = 5.5V	-	-	2	μA		
Output High Voltage	V _{OH2}	Tri-state port	V _{DD} = 4.5V, I _{OH} = -0.7mA	4.1	-	-	V		
Output Low Voltage	V _{OL}	Except XOUT and P3	V _{DD} = 4.5V, I _{OL} = 1.6mA	-	-	0.4	V		
Output Low Current	I _{OL3}	Port P3	V _{DD} = 4.5V, V _{OL} = 1.0V	-	20	-	mA		
Supply Current in NORMAL 1, 2 mode	I _{DD}		V _{DD} = 5.5V, TONE no output	-	9	12	mA		
Supply Current in IDLE 1, 2 mode			V _{IN} = 5.3V/0.2V, TONE output	-	10.5	13.5			
Supply Current in NORMAL 1, 2 mode			f _c = 8 MHz, TONE no output	-	4.5	6.5			
Supply Current in IDLE 1, 2 mode			f _s = 32.768 kHz, TONE output	-	6.0	8.0			
Supply Current in SLOW mode			V _{DD} = 2.2V, TONE no output	-	1.5	2.5			
Supply Current in SLEEP mode	I _{DD}		V _{IN} = 2.2V/0.2V, TONE output	-	2.0	3.0	μA		
Supply Current in STOP mode			f _c = 4.2 MHz, TONE no output	-	0.8	1.8			
			f _s = 32.768 kHz, TONE output	-	1.3	2.3			
Note 1: Typical values show those at Topr = 25°C, V _{DD} = 5 V.									
Note 2: Input current: The current through pull-up or pull-down resistor is not included.									

A/D Conversion Characteristics

(V_{SS} = 0V, V_{DD} = 2.7 to 5.5V, Topr = -30 to 60°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Analog Reference Voltage	V _{AREF}	V _{AREF} - V _{ASS} ≥ 2.5V	2.7	—	V _{DD}	V
	V _{ASS}		V _{SS}	—	1.5	
Analog Input Voltage	V _{AIN}	V _{DD} = V _{AREF} = 5.0V V _{SS} = V _{ASS} = 0.0V	V _{ASS}	—	V _{AREF}	V
Analog Supply Current	I _{REF}		—	0.5	1.0	V
Nonlinearity Error		V _{DD} = 2.7 to 5.5V V _{SS} = 0.0V	—	—	±1	mA
Zero Point Error			—	—	±1	
Full Scale Error		V _{AREF} = 2.700V, 5.000V V _{ASS} = 0.000V	—	—	±1	LSB
Total Error			—	—	±2	

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

Tone Output Characteristics

(V_{SS} = 0V, V_{DD} = 2.2 to 5.5V, Topr = -30 to 60°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Tone Output Voltage (ROW)	V _{TONE}	R _L ≥ 10 kΩ, V _{DD} = 2.2V	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	△f	f _c = 3.84 MHz, 4.00 MHz, 8.00 MHz (Except error of osc. frequency)	—	—	0.70	%
		f _c = 3.58 MHz (Except error of osc. frequency)	—	—	0.66	
		f _c = 4.19 MHz (Except error of osc. frequency)	—	—	0.93	

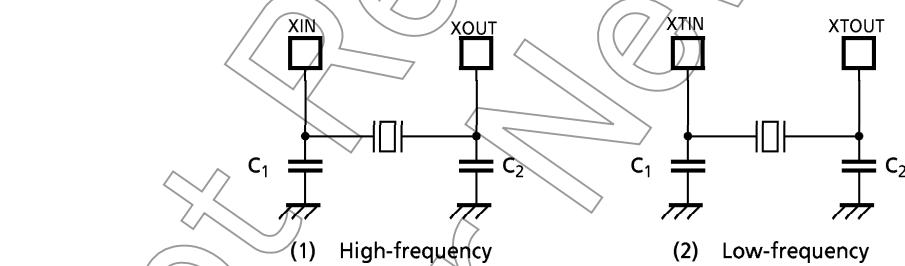
A.C. Characteristics

(V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = -30 to 60°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	t _{cy}	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	—	—	
		In SLEEP mode	—	—	133.3	
High Level Clock Pulse Width	t _{WCH}	For external clock operation (XIN input)	50	—	—	ns
Low Level Clock Pulse Width	t _{WCL}	f _c = 8 MHz				
High Level Clock Pulse Width	t _{WSH}	For external clock operation (XTIN input)	14.7	—	—	μs
Low Level Clock Pulse Width	t _{WSL}	f _s = 32.768 kHz				

Recommended Oscillating Condition

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



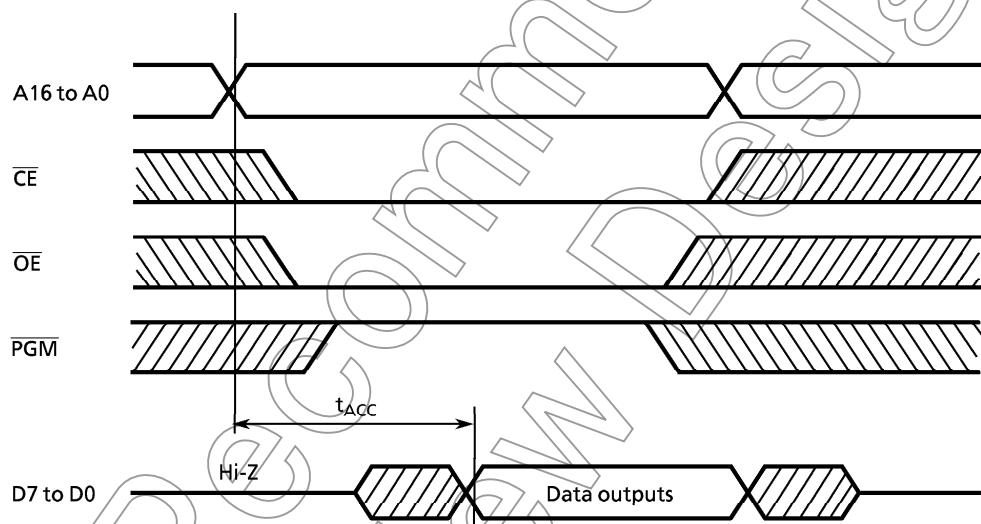
Note: When it is used in high electrical field, an electrical shield of the package is recommended to retain normal operations

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

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

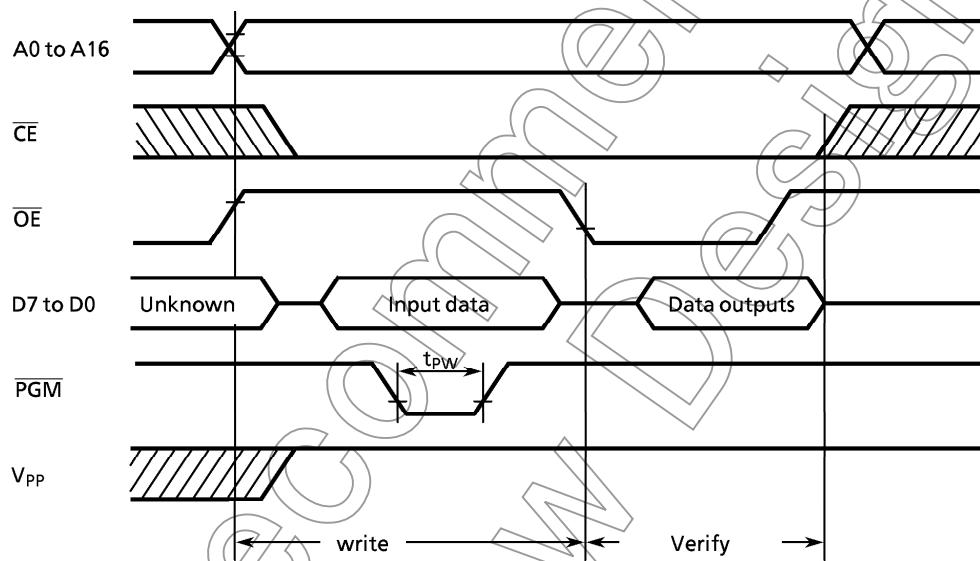
(1) Read Operation

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}		4.75	5.0	5.25	V
Program Power Supply Voltage	V_{PP}					
Address Access Time	t_{ACC}	$V_{CC} = 5.0 \pm 0.25 \text{ V}$		$1.5 \text{ tcyc} + 300$		ns

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

(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 ($12.5\text{ V} \pm 0.5\text{ V} = V$) 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.