TOSHIBA

TOSHIBA Original CMOS 8-Bit Microcontroller

TLCS-870 Series

TMP87PP23FG

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: TMPxxxxxxF → TMPxxxxxxFG

   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
TMP87PP23F	P-QFP100-1420-0.65A	TMP87PP23FG	QFP100-P-1420-0.65Q	—

*: 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.

RESTRICTIONS ON PRODUCT USE 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

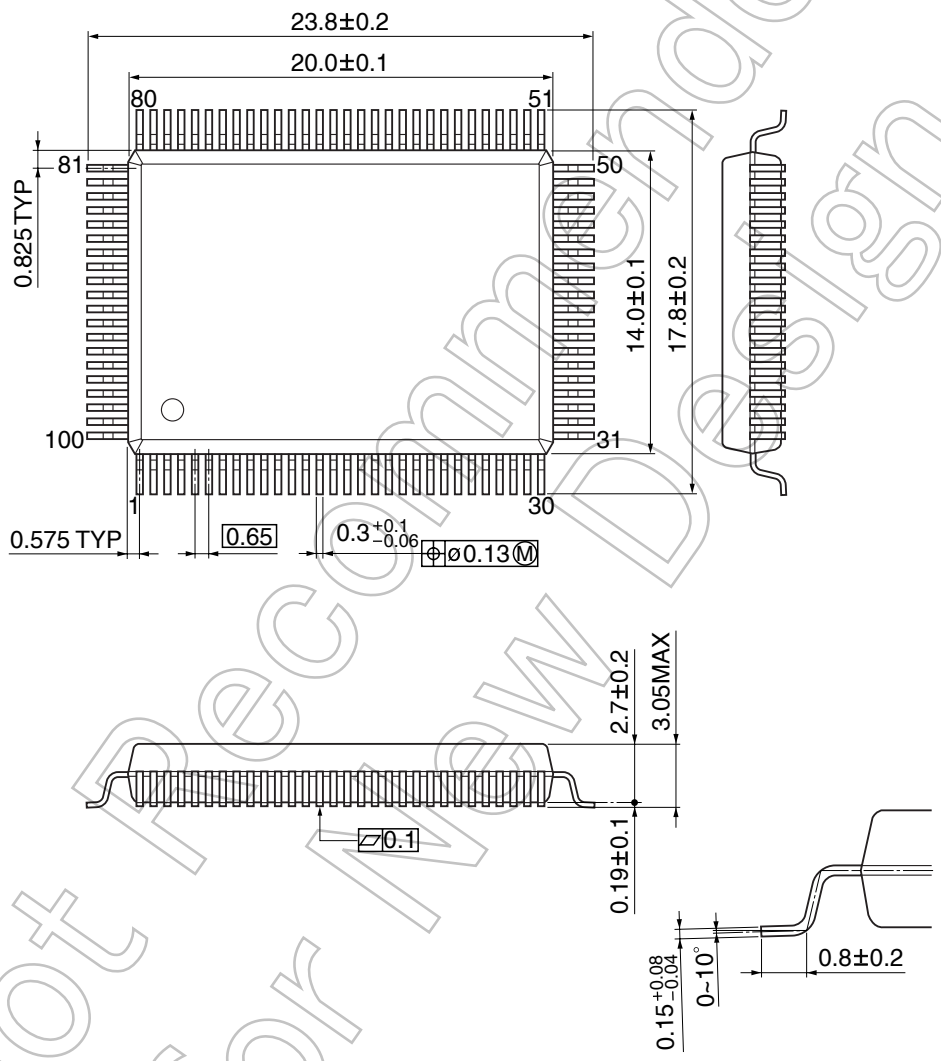
The publication date of this datasheet is printed at the lower right corner of this notification.

(Annex)

Package Dimensions

QFP100-P-1420-0.65Q

Unit: mm



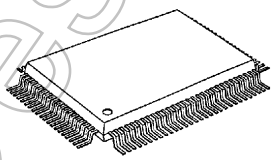
CMOS 8-Bit Microcontroller

TMP87PP23F

The TMP87PP23 is a One-Time PROM microcontroller with low-power 384K bits electrically programmable read only memory for the TMP87CM23A/CP23 system evaluation. The TMP87PP23 is pin compatible with the TMP87CM23A/CP23. The operations possible with the TMP87CM23A/CP23 can be performed by writing programs to PROM. The TMP87PP23 can write and verify in the same way as the TC571000D using an adapter socket BM1185A and an EPROM programmer.

Product No.	OTP	RAM	Package	OTP Adapter
TMP87PP23F	48K × 8-bit	2K × 8-bit	P-QFP100-1420-0.65A	BM1185A

P-QFP100-1420-0.65A



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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.
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OPERATIONAL DESCRIPTION

The following explains the TMP87PP23 hardware configuration and operation. The configuration and functions of the TMP87PP23 are the same as those of the TMP87CM23A/CP23, except in that a one-time PROM is used instead of an on-chip mask ROM.

The TMP87PP23 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 TMP87PP23 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 TMP87CM23A/CP23 (the TEST / VPP pin cannot be used open because it has no built-in pull-down resistance).

1.1.1 Program Memory

The TMP87PP23 has a 48K × 8-bit (addresses 4000_H-$FFFF_H$ in the MCU mode, addresses 14000_H-$1FFFF_H$ in the PROM mode) of program memory (OTP).

When the TMP87PP23 is used as a system evaluation of the TMP87CM23A/P23, the data is written to the program storage area shown in figure 1-1.

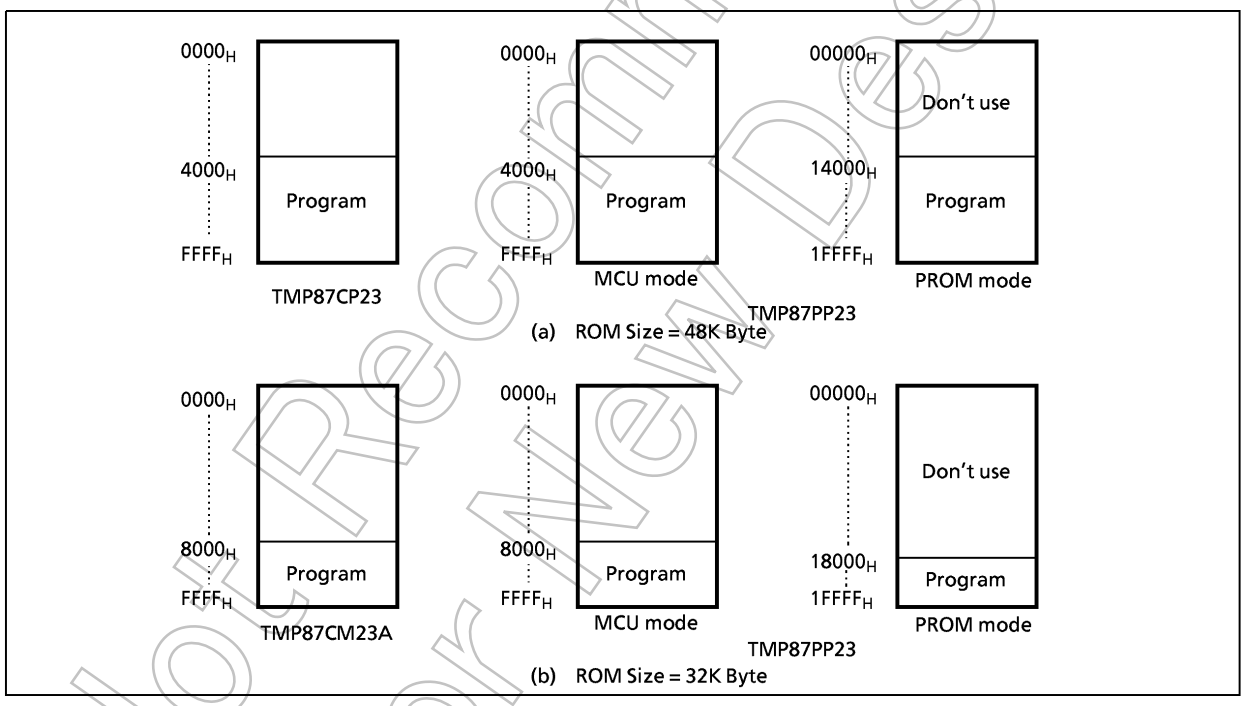


Figure 1-1. Program Memory Area

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 TMP87PP23 has an on-chip 2K × 8-bit data memory (static RAM).

1.1.3 Input/Output Circuitry

(1) Control pins

The control pins of the TMP87PP23 are the same as those of the TMP87CM23A/CP23 except that the TEST pin has no built-in pull-down resistance.

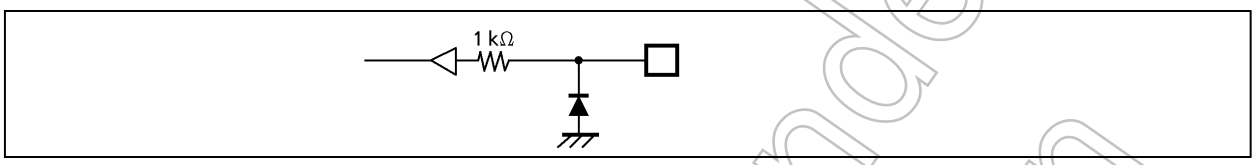


Figure 1-2. TEST Pin

(2) I/O ports

The I/O circuitries of TMP87PP23 I/O ports are the same as the those of TMP87CM23A/CP23.

1.2 PROM mode

The PROM mode is activated by setting the TEST, $\overline{\text{RESET}}$ pin and the ports P17 to P10, P22 to P20 and P61 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 TMP87PP23 is not supported an electric signature mode, so the ROM type must be set to TC571000D.

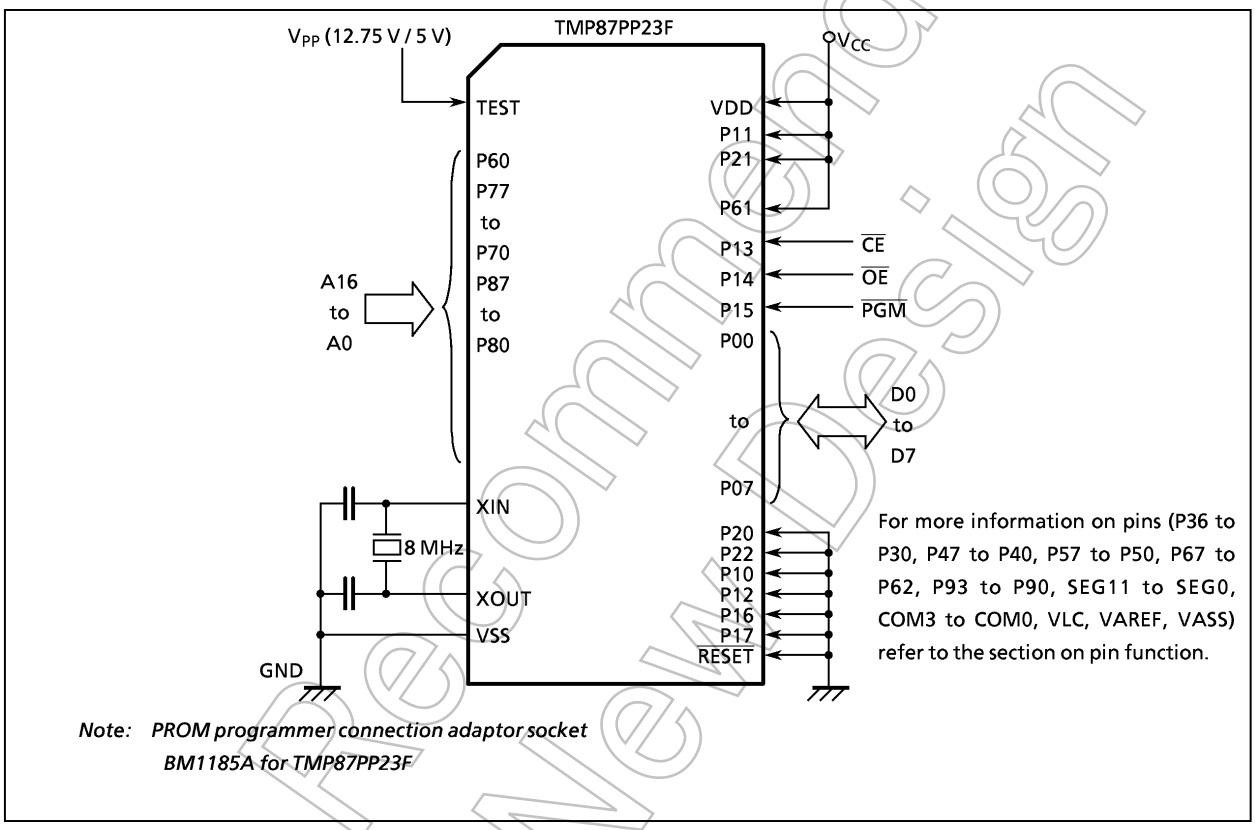


Figure 1-3. Setting for PROM Mode

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 0.1 ms program pulse to the $\overline{PGM}$ 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.

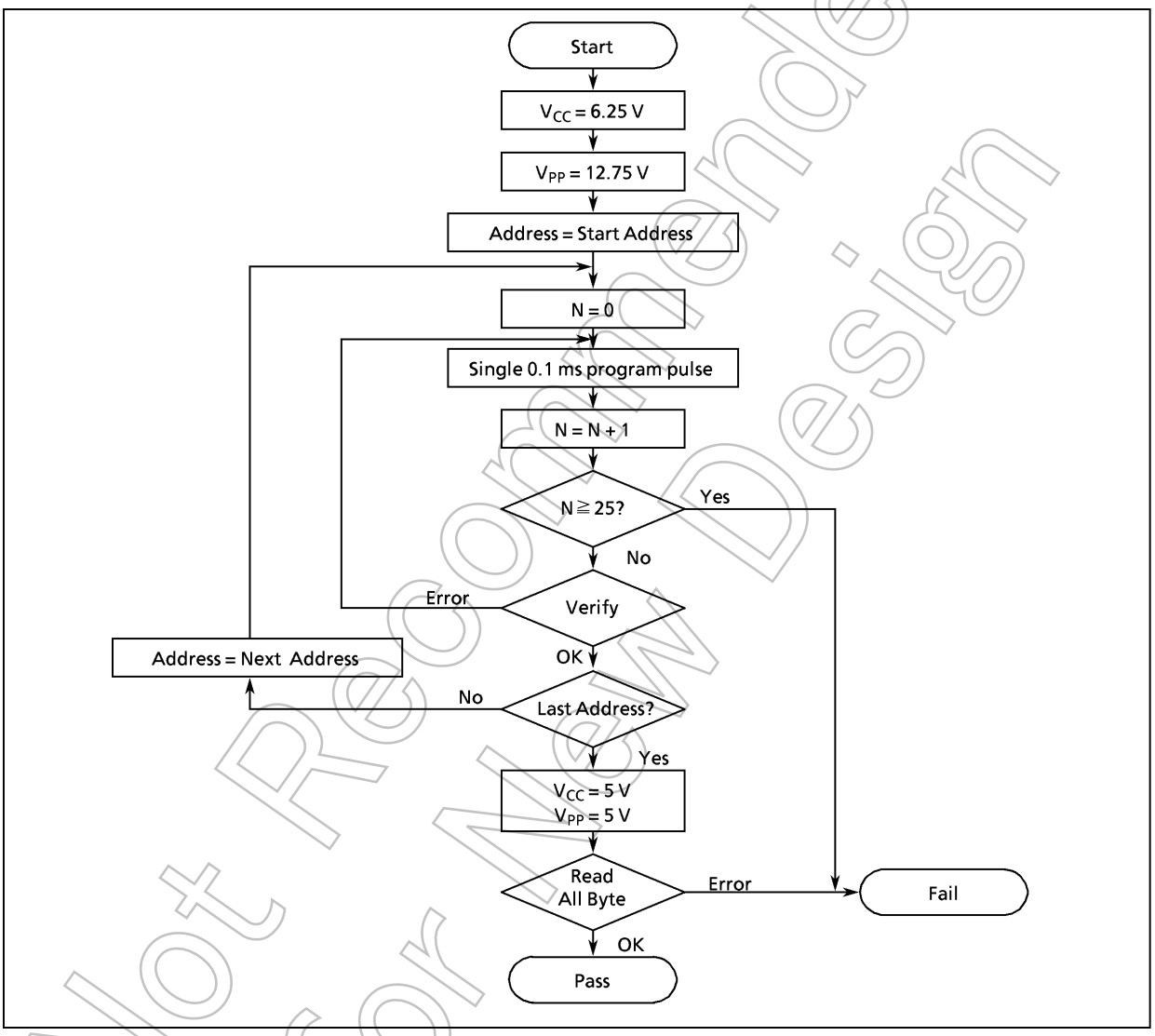


Figure 1-4. Flow Chart of High-speed Programming

1.2.2 Writing method for general-purpose PROM program

(1) Adapters
BM1185A: TMP87PP23F

(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 TMP87PP23, EPROM is within the addresses 14000_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 48KB: transferred addresses 04000_H to $0FFFF_H$ to addresses 14000 to $1FFFF_H$

iii) Writing address is specified. (Note 1)
Start address: 14000_H
End address: $1FFFF_H$

(4) Writing
Writing/Verifying is required to be executed in accordance with PROM programmer operating procedure.

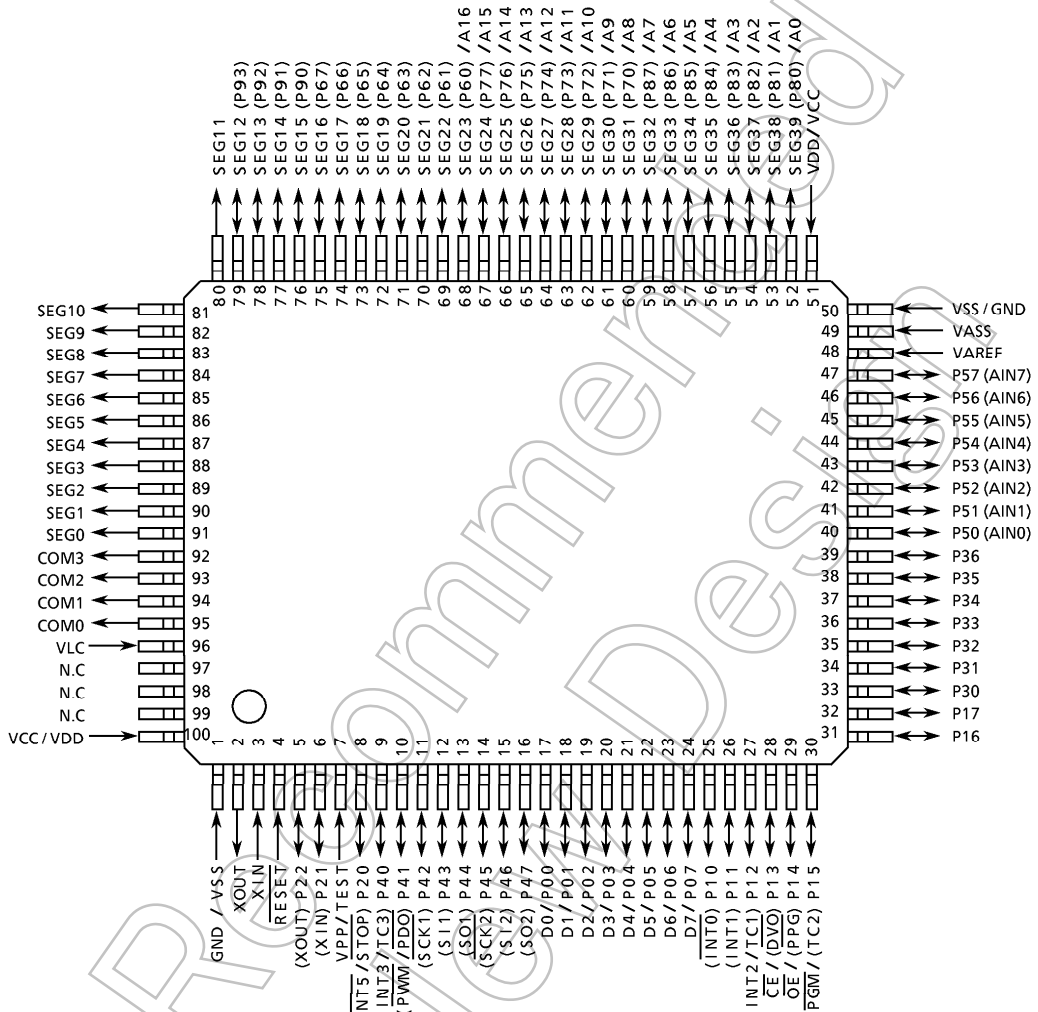
Note 1: The specifying method is referred to the PROM programmer description. Either write the data FF_H to the unused area or set the PROM programmer to access only the program storage area.

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 TMP87PP23 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 12V ± 0.5V to the address pin 9 (A9). The signature must not be used.

Pin Assignments (Top View)

P-QFP100-1420-0.65A



Pin Function

The TMP87PP23 has two modes: MCU and PROM.

(1) MCU mode

In this mode, the TMP87PP23 is pin compatible with the TMP87CM23A/CP23 (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 (active low)	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.	
P47 to P40			
P57 to P50			
P67 to P62			
P93 to P90			
P11		PROM mode setting pin. Be fixed at high level.	
P21			
P61			
P17, P16, P12, P10 P22, P20		PROM mode setting pin. Be fixed at low level.	
$\overline{RESET}$			
XIN	Input	Connect an 8MHz oscillator to stabilize the internal state.	
XOUT	Output		
VAREF	Power supply	0 V (GND)	
VASS			
COM3 to COM0	Output	Open	
SEG11 to SEG0			
VLC	Power supply		

Electrical Characteristics

Absolute Maximum Ratings (V_{SS} = 0 V)

Parameter	Symbol	Pin	Ratings	Unit
Supply Voltage	V_{DD}		– 0.3 to 6.5	V
Program Voltage	V_{PP}	TEST/V_{PP}	– 0.3 to 13.0	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 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)	ΣI_{OUT1}	Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41)	120	mA
	ΣI_{OUT2}	P41	30	
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

Note1: 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.

Note 2: The absolute maximum input/output voltage ratings for the TMP87CM23A/CP23/PP23 are – 0.3 to VDD + 0.3 [V] at all I/O ports including sink open drain output ports. (However, the VPP pin of TMP87PP23 is not contained in these condition.)

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

Parameter	Symbol	Pin	Condition		Min	Max	Unit
Supply Voltage	V_{DD}		fc = 8 MHz	NORMAL1, 2 mode	4.5	5.5	V
				IDLE1, 2 mode			
			fc = 4.2 MHz	NORMAL1, 2 mode	2.7		
				IDLE1, 2 mode			
			fs = 32.768 kHz	SLOW mode			
				SLEEP mode			
				STOP mode	2.0		
Input High Voltage	V_{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	V_{DD} = 4.5 to 5.5 V		0.4	8.0	MHz
			V_{DD} = 2.7 to 5.5 V			4.2	
	fs	XTIN, XTOUT			30.0	34.0	kHz

Note 1: The recommended operating conditions for a device are operating conditions under which it can be guaranteed that the device will operate as specified. If the device is used under operating conditions other than the recommended operating conditions (supply voltage, operating temperature range, specified AC/DC values etc.), malfunction may occur. Thus, when designing products which include this device, ensure that the recommended operating conditions for the device are always adhered to.

Note 2: Clock frequency fc: Supply voltage range is specified in NORMAL1/2 mode and IDLE1/2 mode.

DC Characteristics

(V_{SS} = 0 V, Topr = – 30 to 70°C)

Parameter	Symbol	Pin	Condition	Min	Typ.	Max	Unit
Hysteresis Voltage	V_{HS}	Hysteresis inputs		—	0.9	—	V
Input Current	I_{IN1}	TEST	V_{DD} = 5.5 V, V_{IN} = 5.5 V / 0 V	—	—	± 2	μA
	I_{IN2}	Open drain ports and tri-state ports					
	I_{IN3}	$\overline{RESET}$, $\overline{STOP}$					
Input Low Current	I_{IL}	Push-pull ports	V_{DD} = 5.5 V, V_{IN} = 0.4 V	—	—	– 2	mA
Input Resistance	R_{IN2}	$\overline{RESET}$		100	220	450	kΩ
Output Leakage Current	I_{LO}	Open drain ports	V_{DD} = 5.5 V, V_{OUT} = 5.5 V	—	—	2	μA
Segment Output Low Resistance	R_{OS1}	SEG39 to SEG0	V_{DD} = 5 V, $V_{DD} - V_{LC}$ = 3 V	—	20	—	kΩ
Common Output Low Resistance	R_{OC1}	COM3 to COM0					
Segment Output High Resistance	R_{OS2}	SEG39 to SEG0		—	200	—	kΩ
Common Output High Resistance	R_{OC2}	COM3 to COM0					
Segment/Common Output Voltage	$V_{O\ 2/3}$	SEG39 to SEG0 and COM3 to COM0		3.8	4.0	4.2	V
	$V_{O\ 1/2}$			3.3	3.5	3.7	
	$V_{O\ 1/3}$			2.8	3.0	3.2	
Output High Voltage	V_{OH1}	Push-pull ports (P4 port)	V_{DD} = 4.5 V, I_{OH} = – 200 μA	2.4	—	—	V
	V_{OH2}	Tri- state ports (P0, P1, P5 ports)	V_{DD} = 4.5 V, I_{OH} = – 0.7 mA	4.1	—	—	
Output Low Voltage	V_{OL}	Except XOUT and P41	V_{DD} = 4.5 V, I_{OL} = 1.6 mA	—	—	0.4	V
Output Low Current	I_{OL3}	P41	V_{DD} = 4.5 V, V_{OL} = 1.0 V	—	20	—	mA
Supply Current in NORMAL 1 , 2 mode	I_{DD}		V_{DD} = 5.5 V fc = 8 MHz fs = 32.768 kHz V_{IN} = 5.3 V / 0.2 V	—	12	18	mA
Supply Current in IDLE 1, 2 mode				—	6	10	
Supply Current in SLOW mode			V_{DD} = 3.0 V fs = 32.768 kHz V_{IN} = 2.8 V / 0.2 V LCD driver is not enable	—	30	60	μA
Supply Current in SLEEP mode				—	15	30	μA
Supply Current in STOP mode			V_{DD} = 5.5 V 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 ; The current through pull-up or pull-down resistor is not included.
Note 3: I_{DD} ; Except for I_{REF}
Note 4: Output resistors Ros, Roc indicate "on" when switching levels.
Note 5: $V_{O2/3}$ indicates an output voltage at the 2/3 level when operating in the 1/4 or 1/3 duty mode.
Note 6: $V_{O1/2}$ indicates an output voltage at the 1/2 level when operating in the 1/2 duty or static mode.
Note 7: $V_{O1/3}$ indicates an output voltage at the 1/3 level when operating in the 1/4 or 1/3 duty mode.
Note 8: When using LCD, it is necessary to consider values of Ros1/2 and Rbc1/2.
Note 9: Times for SEG/COM output switching on: Ros1, Roc1: 2^6/fc, 2/fc (s)
Ros2, Roc2: 1/(n, f_F)
(1/n: duty, f_F: frame frequency)

AD Conversion Characteristics

(V_{SS} = 0V, V_{DD} = 2.7 to 5.5V, Topr = – 30 to 70°C)

ParameteR	Symbol	Condition	Min	Typ.	Max	Unit
Analog Reference Voltage	V_{AREF}	$V_{AREF} - V_{ASS} \geqq 2.5$ V	2.7	–	V_{DD}	V
	V_{ASS}		V_{SS}	–	1.5	
Analog Input Voltage	V_{AIN}		V_{ASS}	–	V_{AREF}	V
Analog Supply Current	I_{REF}	V_{AREF} = 5.5 V, V_{ASS} = 0.0 V	–	0.5	1.0	mA
Nonlinearity Error		V_{DD} = 5.0 V, V_{SS} = 0.0 V V_{AREF} = 5.000 V V_{ASS} = 0.000 V or V_{DD} = 2.7 V, V_{SS} = 0.0 V V_{AREF} = 2.700 V V_{ASS} = 0.000 V	–	–	± 1	LSB
Zero Point Error			–	–	± 1	
Full Scale Error			–	–	± 1	
Total Error			–	–	± 2	

Note: Quantizing error is not contained in those errors.

AC Characteristics

(V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Machine Cycle Time	t_{cy}	In NORMAL 1, 2 mode	0.95	–	10	μs
		In IDLE 1, 2 mode				
		In SLOW mode	117.6	–	133.3	
		In SLEEP mode				
High Level Clock Pulse Width	t_{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}					

(V_{SS} = 0 V, V_{DD} = 2.7 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Machine Cycle Time	t_{cy}	In NORMAL 1, 2 mode	0.95	–	10	μs
		In IDLE 1, 2 mode				
		In SLOW mode	117.6	–	133.3	
		In SLEEP mode				
High Level Clock Pulse Width	t_{WCH}	For external clock operation (XIN input), fc = 8 MHz	110	–	–	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}					

Recomended Oscillating Condition-1

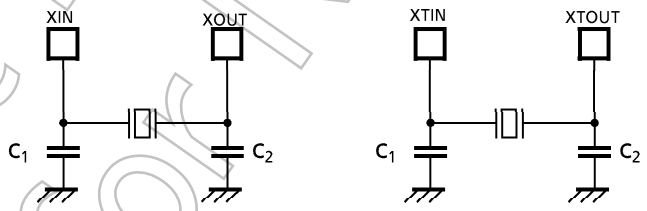
(VSS = 0 V, VDD = 4.5 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Osillator	Frequency	Recommender Oscillator		Recommended COndition C_1	Recommended COndition C_2
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
		4 MHz	KYOCERA	KBR4.0MS	30pF	30pF
	Crystal Oscillator	8 MHz	TOYOCOM	210B 8.0000	20pF	20pF
		4 MHz	TOYOCOM	204B 4.0000		
Low-frequency	Crystal Oscillator	32.768 kHz	NDK	MX-38T	15pF	15pF

Recomended Oscillating Condition-2

(VSS = 0 V, VDD = 2.7 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Osillator	Frequency	Recommender Oscillator		Recommended Condition C_1	Recommended Condition C_2
High-frequency	Ceramic Resonator	4 MHz	Standard/Lead Type (MURATA)	CSA4.00MG	30pF	30pF
				CST4.00MGW	Built-in 30pF	Built-in 30pF
			Standard/SMD Type (MURATA)	CSA4.00MGC CSAC4.00MGCM CSTC4.00MG	30pF	30pF
					Built-in 30pF	Built-in 30pF
			Standard/Small Chip Type	CSTCS4.00MG	Built-in 10pF	Built-in 10pF



(1) High-frequency (2) Low-frequency

Note 1: When used in high electric field such as a picture tube, the package is recommended to be electrically shielded to maintain a regular operation.

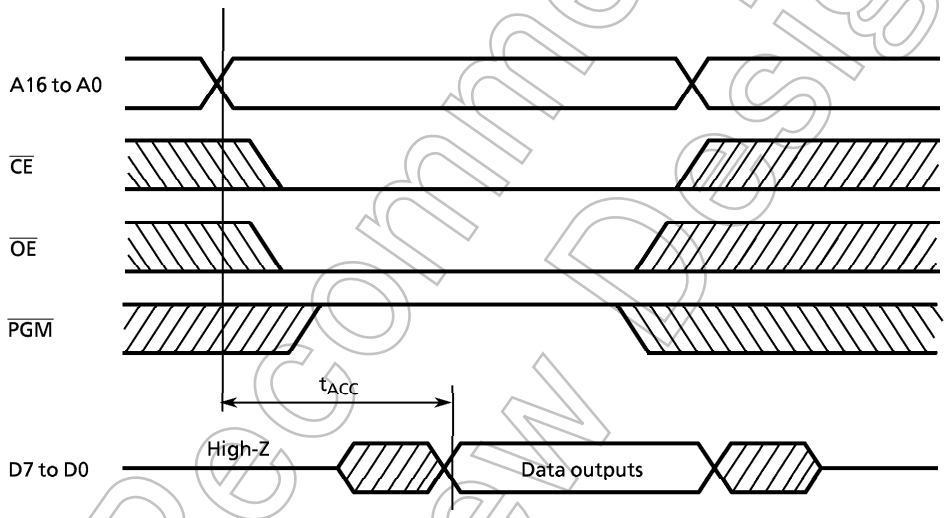
Note 2: The product numbers and specifications of the resonators by Murata Manufacturing Co., Ltd. are subject to change. For up-to-date information, please refer to the following URL; http://www.murata.co.jp/search/index.html

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

(1) Read Operation

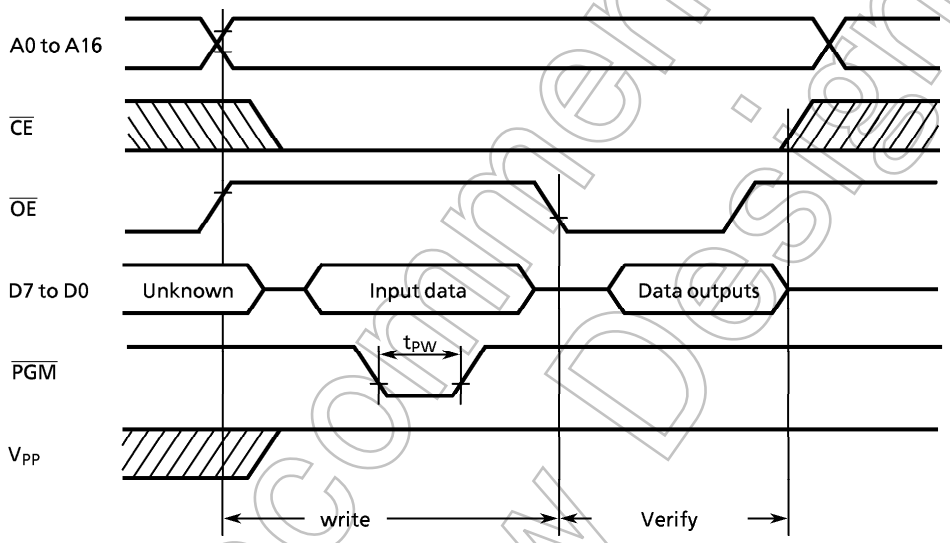
Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Input High Voltage	V_{IH4}		$V_{CC} \times 0.7$	–	V_{CC}	V
Input Low Voltage	V_{IL4}		0	–	$V_{CC} \times 0.12$	V
Power Supply Voltage	V_{CC}		4.75	5.0	5.25	V
Program Power Supply Voltage	V_{PP}					
Address Access Time	t_{ACC}	V_{CC} = 5.0 ± 0.25 V	–	1.5tcyc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

Note: tcyc = 500 ns at 8 MHz



(2) High-Speed Programming Operation

Parameter	Symbol	Condition	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}		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 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 op from it under applying the program voltage (12.5 V ± 0.5 V = V) to the V_{pp} pin as the device is damaged.
Note 3: Be sure to execute the recommended programing mode with the recommended programing adaptor. If a mode or an adaptor except the above, the misoperation sometimes occurs.