CMOS 8-Bit Microcontroller

TMP87CM24AF, TMP87CP24AF

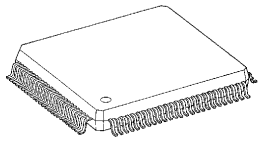
The TMP87CM24A/P24A are the high speed and high performance 8-bit single chip microcomputers. These MCU contain, large ROM, RAM, input/output ports, LCD driver, a 8-bit AD converter, four multi-function timer/counters, two serial interfaces, and two clock generators on chip.

Product No.	ROM	RAM	Package	OTP MCU
TMP87CM24A	32 K × 8 bits	2 K × 8 bits	P-LQFP100-1414-0.50C	TMP87PP24A
TMP87CP24A	48 K × 8 bits			

Features

- ◆8-bit single chip microcomputer TLCS-870 Series
- ◆Instruction execution time: 0.5 μs (at 8 MHz), 122 μs (at 32 kHz)
- ◆129 types and 412 basic instructions
  - Multiplication and Division (8 bits × 8 bits , 16 bits ÷ 8 bits): Execution time 3.5 μs (at 8 MHz)
  - Bit manipulations (Set/Clear/Complement/Load/Store/Test/Exclusive OR)
  - 16-bit data operations
  - 1-byte jump/call (Short relative jump/Vector call)
- ◆14 interrupt sources (External: 5, Internal: 9)
  - All sources have independent latches each, and nested interrupt control is available
  - 4 edge-selectable external interrupts with noise reject
  - High-speed task switching by register bank changeover
- ◆10-input/output ports (Max 69 pins)
- ◆Two 16-bit timer/counters
  - Timer, Event counter, External trigger timer, Window, PPG output Pulse width measurement modes
- ◆Two 8-bit timer/counters
  - Timer, Event counter, Capture (Pulse width/duty measurement), PWM output, PDO modes
- ◆Time Base Timer (Interrupt frequency: 1 Hz to 16384 kHz)
- ◆Divider output function (frequency: 1 kHz to 8 kHz)
- ◆Watchdog Timer
- ◆Two 8-bit Serial Interfaces
  - Each 8 bytes transmit/receive data buffer
  - Internal/external serial clock, and 4-/8-bit mode

P-LQFP100-1414-0.50C



TMP87CM24AF
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TMP87PP24AF

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◆LCD driver
- Built-in voltage booster for LCD driver
- With display memory (20 bytes)
- LCD direct drive capability (Max 40 seg × 4 com)
- 1/4, 1/3, 1/2 duty or static drive are programmably selectable

◆8-bit successive approximate type AD converter with sample and hold
- 8 analog inputs
- Conversion time:23 μs/92 μs (at 8 MHz)

◆Dual clock operation (optional)

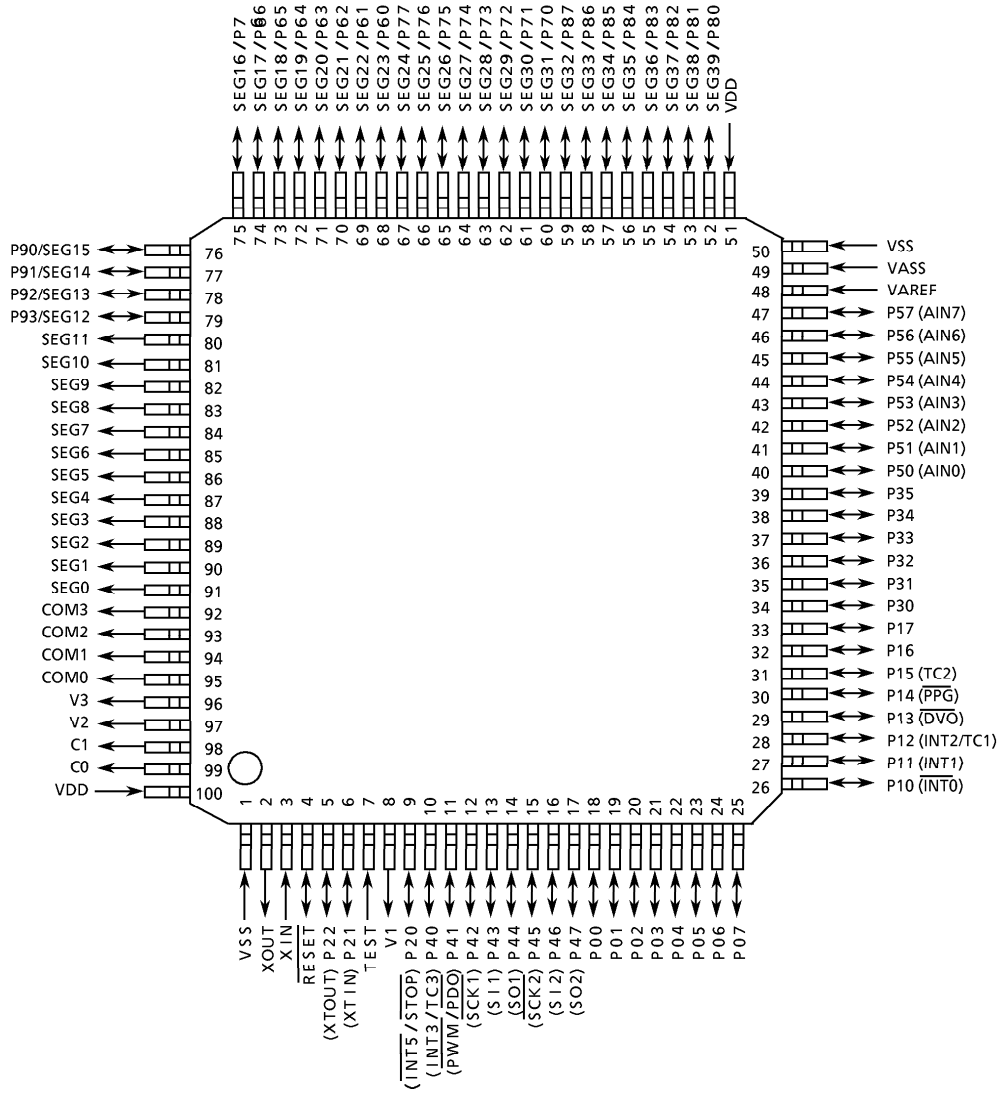
◆Five Power saving operating modes
- STOP mode: Oscillation stops. Battery/Capacitor back-up. Port output hold/high-impedance.
- SLOW mode: Low power consumption operation using low-frequency clock (32.768 kHz).
- IDLE1 mode: CPU stops, and Peripherals operate using high-frequency clock. Release by interrupts.
- IDLE2 mode: CPU stops, and Peripherals operate using high and low frequency clock. Release by interrupts.
- SLEEP mode: CPU stops, and Peripherals operate using low-frequency clock. Release by interrupts.

◆Operating Voltage: 2.2 to 5.5 V at 4.2 MHz/32.768 kHz, 4.5 to 5.5 V at 8 MHz/32.768 kHz

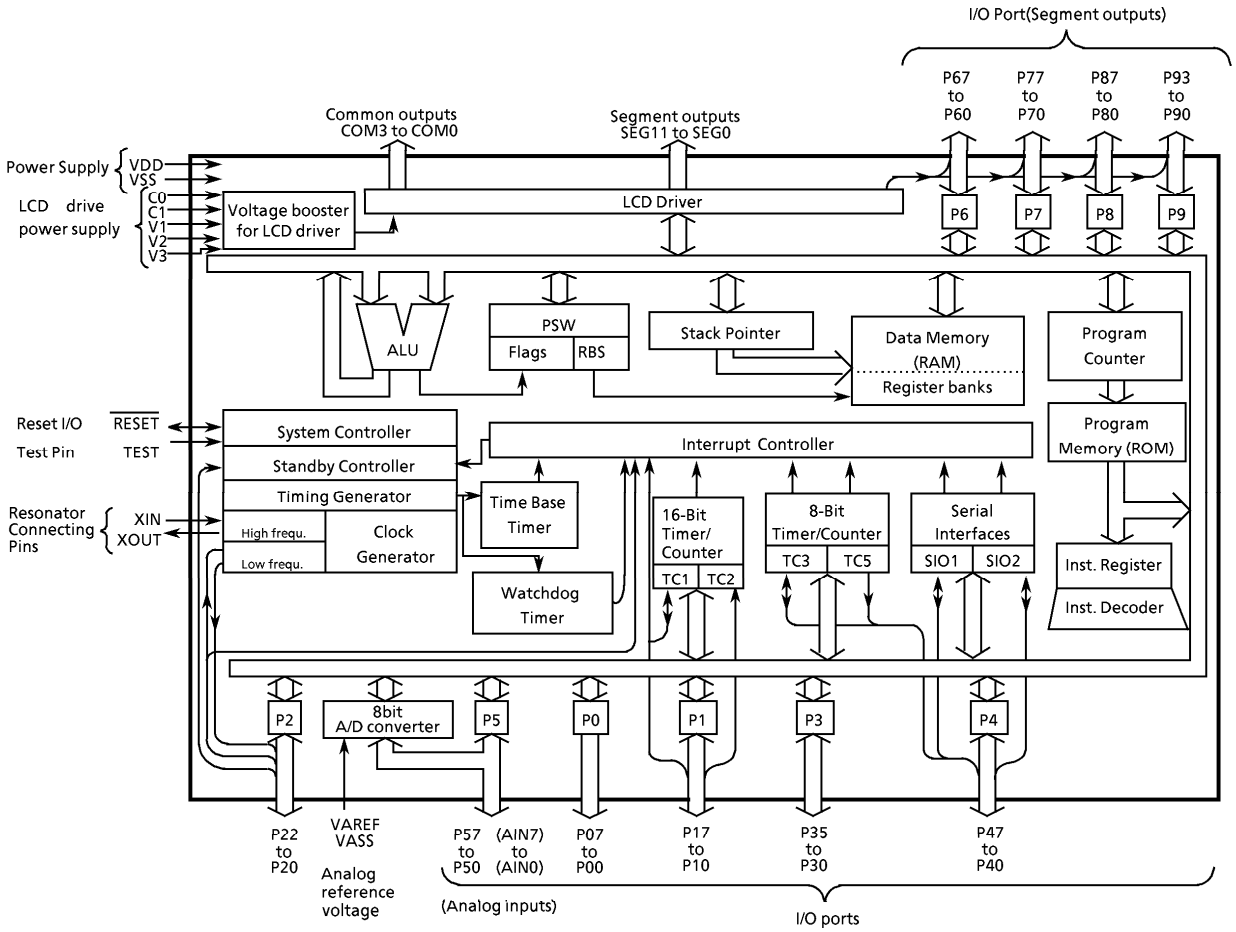
◆Emulation Pod: BM87CP24F0A

Pin Assignments (Top View)

P-LQFP100-1414-0.50C



Block Diagram



Pin Functions

Pin Name	Input/Output	Function	
P07 to P00 P17, P16	I/O	8-bit programmable input/output ports (tri-state). Each bit of these ports can be individually configured as an input or an output under software control. When used as an input port, timer/counter input or external interrupt input, the P0CR/P1CR must be set to "0". When used as timer/counter output or divider output, the P0CR/P1CR must be set to "1" after setting output latch to "1".	
P15 (TC2)	I/O (Input)		Timer/Counter 2 input
P14 ($\overline{PPG}$)	I/O (Output)		Programmable pulse generator output
P13 ($\overline{DVO}$)			Divider output
P12 (INT2/TC1)	I/O (Input)		External interrupt 2 input or Timer/Counter 1 input
P11 (INT1)			External interrupt 1 input
P10 ($\overline{INT0}$)			External interrupt 0 input
P22 (XTOUT)	I/O (Output)	3-bit input/output port with latch. When used as an input port, external interrupt input or STOP mode release input, the output latch must be set to "1".	Resonator connecting pins (32.768 kHz).
P21 (XTIN)	I/O (Input)		For inputting external clock, XTIN is used and XTOUT is opened.
P20 ($\overline{INT5}$/$\overline{STOP}$)			External interrupt 5 input or STOP mode release signal input
P35 to P30	I/O	6-bit input/output port with latch. When used as input port, the output latch must be set to "1".	
P47 (SO2)	I/O (Output)	8-bit input/output port with latch. When used as serial interface output or timer/counter output, the P4CR1 must be set to "1" after setting output latch to "1". When used as an input port, serial interface input or external interrupt input, the P4CR1 must be set to "0".	SIO2 serial data output
P46 (SI2)	I/O (Input)		SIO2 serial data input
P45 ($\overline{SCK2}$)	I/O (I/O)		SIO2 serial clock input/output
P44 (SO1)	I/O (Output)		SIO1 serial data output
P43 (SI1)	I/O (Input)		SIO1 serial data input
P42 ($\overline{SCK1}$)	I/O (I/O)		SIO1 serial clock input/output
P41 ($\overline{PWM}$/$\overline{PDO}$)	I/O (Output)		8-bit PWM output, 8-bit programmable divider output
P40 (INT3/TC3)	I/O (Input)		External interrupt 3 input, Timer/Counter 3 input
P57 (AIN07) to P50 (AIN00)	I/O (Input)	8-bit programmable input/output port (tri-state). Each bit of the port can be individually configured as an input or an output under software control. When used as analog input, the P5CR must be set to "0".	AD converter analog inputs
SEG39 (P80) to SEG32 (P87)	Output (I/O)	8-bit input/output port with latch. When used as an input port, the segment output control register must be set to "0" after setting output latch to "1".	LCD segment outputs. When used as segment output, the segment output control register must be set to "1".
SEG31 (P70) to SEG24 (P77)	Output (I/O)		
SEG23 (P60) to SEG16 (P67)	Output (I/O)		
SEG15 (P90) to SEG12 (P93)	Output (I/O)	4-bit input /output port with latch. When used as an input port, the segment output control register must be set to "0" after setting output latch to "1".	
SEG11 to SEG0	Output	LCD segment outputs	
COM3 to COM0	Output	LCD common outputs	
XIN, XOUT	Input, Output	Resonator connecting pins for high-frequency clock. For inputting external clock, XIN is used and XOUT is opened.	
$\overline{RESET}$	I/O	Reset signal input or watchdog timer output/address-trap-reset output	
TEST	Input	Test pin for out-going test. Be fixed to low.	
VDD, VSS	Power Supply	+ 5 V, 0 V (GND)	
VAREF, VASS		Analog reference voltage inputs (High, Low)	
C0, C1, V1, V2, V3	LCD voltage booster pin	LCD voltage booster pin. Capacitors are required between C0 and C1 pin and between V1/V2/V3 pin and GND.	

Operational Description

1. CPU Core Functions

The CPU core consists of a CPU, a system clock controller, an interrupt controller, and a watchdog timer. This section provides a description of the CPU core, the program memory (ROM), the data memory (RAM), and the reset circuit.

1.1 Memory Address Map

The TLCS-870 Series is capable of addressing 64K bytes of memory. Figure 1-1 shows the memory address maps of the TMP87CM24A/P24A. In the TLCS-870 Series, the memory is organized 4 address spaces (ROM, RAM, SFR, and DBR). It uses a memory mapped I/O system, and all I/O registers are mapped in the SFR/DBR address spaces. There are 16 banks of general-purpose registers. The register banks are also assigned to the first 128 bytes of the RAM address space.

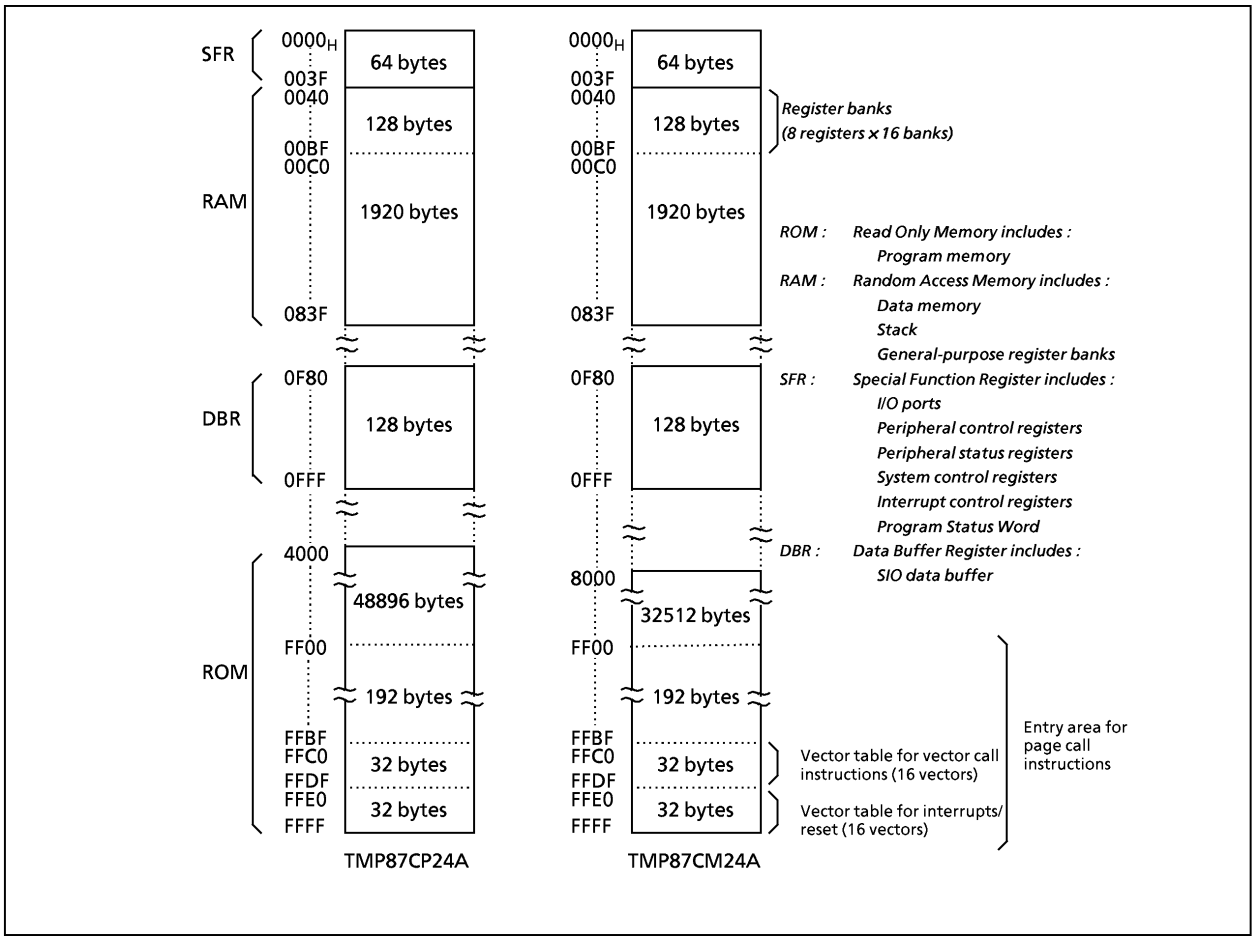


Figure 1-1. Memory Address Maps

Electrical Characteristics

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

Parameter	Symbol	Pins	Ratings	Unit
Supply Voltage	V_{DD}		– 0.3 to 6.5	V
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	
	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)	ΣI_{OUT1}	Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41)	120	
	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	
Operating Temperature	Topr		– 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 V, Topr = – 10 to 70°C)

Parameter	Symbol	Pins	Conditions		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	2.2		
				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_{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_{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} = 2.2 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 = – 10 to 70°C)

Parameter	Symbol	Pins	Conditions	Min	Typ.	Max	Unit
Hysteresis Voltage	V_{HS}	Hysteresis inputs		—	0.9	—	V
Input Current	I_{IN1}	TEST	V_{DD} = 5.5 V, 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_{LO1}	Open drain ports	V_{DD} = 5.5 V, V_{OUT} = 5.5 V	—	—	2	μA
	I_{LO2}	Tri-state ports	V_{OUT} = 5.5 V/0 V	—	—	± 2	
Segment/Common Output Voltage	V_{LCD1}	SEG39 to SEG0 and COM3 to COM0		0.75	1.0	1.33	V
	V_{LCD2}			V_{LCD1} × 2			
	V_{LCD3}			V_{LCD1} × 3			
Output High Voltage	V_{OH1}	Push-pull ports (P4 port)	V_{DD} = 4.5 V, I_{OH} = – 200 μA	2.4	—	—	
	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	
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	—	10	16	
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 Voltage boost frequency = 1 kHz	—	30	70	μA
Supply Current in SLEEP mode				—	15	40	
Supply Current in STOP mode			V_{DD} = 5.5 V V_{IN} = 5.3 V/0.2 V	—	0.5	10	

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: V_{LCD2} indicates an output voltage at the 2/3 level when operating in the 1/4 or 1/3 duty mode.
Note 5: V_{LCD1} indicates an output voltage at the 1/3 level when operating in the 1/4 or 1/3 duty mode.
Note6: SEG/COM output voltage indicates an output voltage at no local.

Topr [°C]	V_{LCD1}			Unit
	Min	typ.	Max	
– 10	1.03	–	1.33	V
25	0.85	1.0	1.15	
70	0.75	–	1.00	

AD Conversion Characteristics (Ⅰ) (Topr = – 10 to 70°C)

Parameter	Symbol	Conditions	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	$\triangle V_{AREF}$		2.5	–	–	
Analog Input Voltage	V_{AIN}		V_{ASS}	–	V_{AREF}	
Analog Supply Current	I_{REF}	V_{AREF} = 5.5 V, V_{ASS} = 0.0 V	–	0.5	1.0	mA
Nonlinearity Error		V_{DD} = 2.7 V to 5.0 V, V_{SS} = 0.0 V V_{AREF} = 5.000 V, 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.

AD Conversion Characteristics (Ⅱ) (Topr = – 10 to 70°C)

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

Note: Quantizing error is not contained in those errors.

AC Characteristics (I) (V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = – 10 to 70°C)

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	t_{cy}	In NORMAL1, 2 modes	0.5	–	10	μs
		In IDLE 1, 2 modes				
		In SLOW mode	117.6	–	133.3	
		In SLEEP mode				
High Level Clock Pulse Width	t_{WCH}	For external clock operation (XIN input), fc = 8 MHz	50	–	–	ns
Low Level Clock Pulse Width	t_{WCL}					
High Level Clock Pulse Width	t_{WSH}	For external clock operation (XTIN input), fs = 32.768 kHz	14.7	–	–	μs
Low Level Clock Pulse Width	t_{WSL}					

AC Characteristics (II) (V_{SS} = 0 V, V_{DD} = 2.2 to 5.5 V, Topr = – 10 to 70°C)

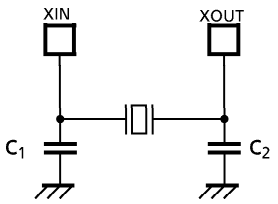
Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	t_{cy}	In NORMAL1, 2 modes	0.95	–	10	μs
		In IDLE 1, 2 modes				
		In SLOW mode	117.6	–	133.3	
		In SLEEP mode				
High Level Clock Pulse Width	t_{WCH}	For external clock operation (XIN input), fc = 4.2 MHz	110	–	–	ns
Low Level Clock Pulse 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 (Ⅰ) (V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = − 10 to 70°C)

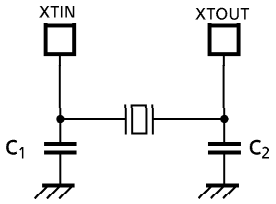
Parameter	Osillator	Frequency	Recommender Oscillator		Recommended Condition C_1	Recommended Condition C_2
High-frequency	Ceramic Resonator	8 MHz	KYOCERA	KBR8.0M	30 pF	30 pF
			Standard/Lead Type (MURATA)	CSA8.00MTZ CST8.00MTW	built-in 30 pF	built-in 30 pF
			Standard/SMP Type (MURATA)	CSACS8.00MT	30 pF	30 pF
			Standard/Small ChipType (MURATA)	CSTCS8.00MT	built-in 30 pF	built-in 30 pF
		4 MHz	KYOCERA	KBR4.0MS	30 pF	30 pF
	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

Recomended OScillating Condition (Ⅱ) (V_{SS} = 0 V, V_{DD} = 2.2 to 5.5 V, Topr = − 10 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	CSA4.00MG	30 pF	30pF
			(MURATA)	CST4.00MGW	built-in 30 pF	built-in 30 pF
			Standard/SMD Type (MURATA)	CSA4.00MGC CSAC4.00MGCM CSTC4.00MG	30 pF	30 pF
					built-in 30 pF	built-in 30 pF
			Standard/Small Chip Type	CSTCS4.00MG	built-in 10 pF	built-in 10 pF



(1) High-frequency



(2) Low-frequency

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

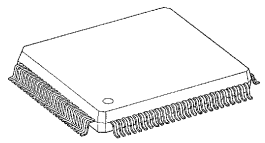
CMOS 8-Bit Microcontroller

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

P-LQFP100-1414-0.50C



TMP87PP24AF

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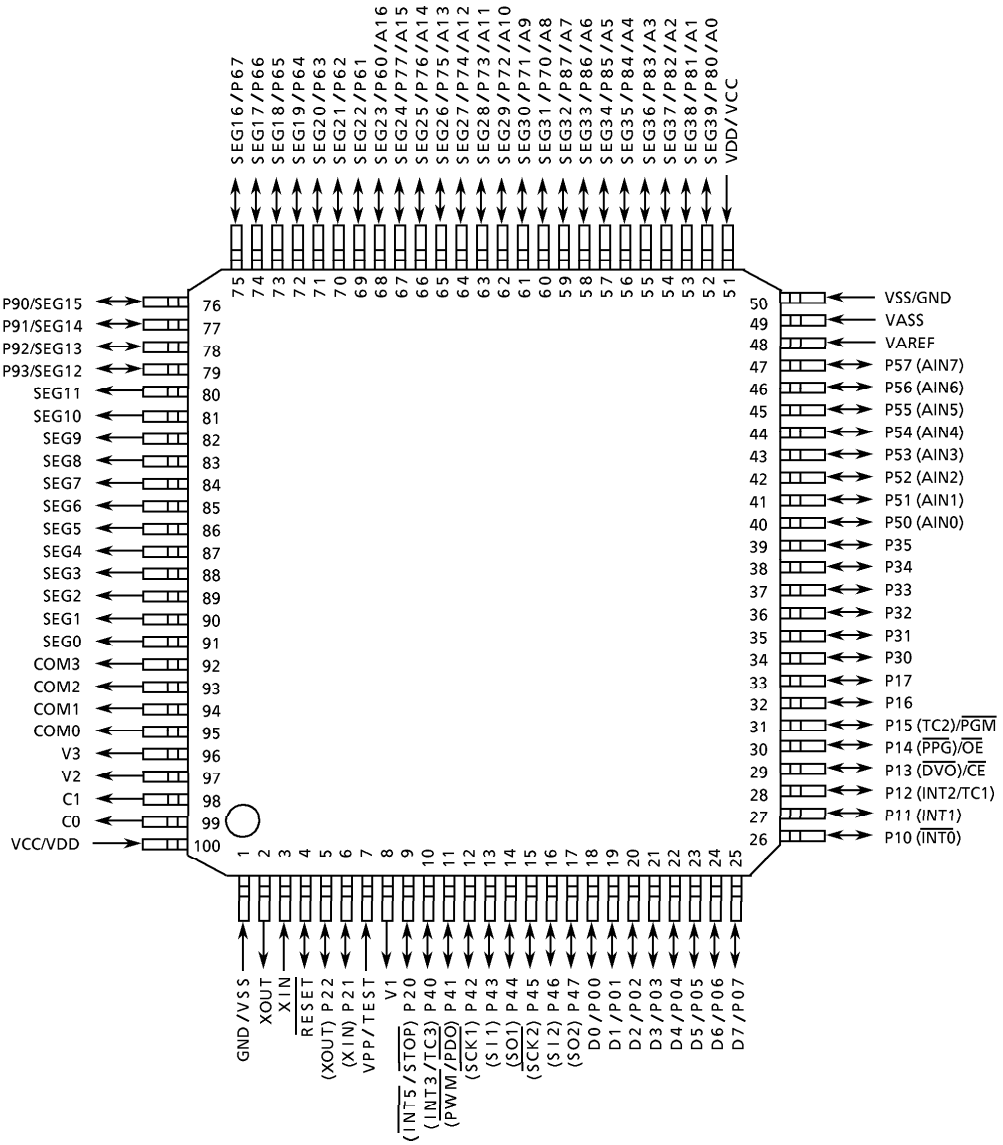
- The information contained herein is subject to change without notice.

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.	
P47 to P40			
P57 to P50			
P67 to P62			
P93 to P90			
P11		PROM mode setting pin. Be fixed at high level.	
P21			
P31			
P61			
P17, P16, P12, P10 P22, P20		PROM mode setting pin. Be fixed at low level.	
$\overline{RESET}$			
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_H to $FFFF_H$ in the MCU mode, addresses 14000_H to $1FFFF_H$ 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_H to the unused area or set the PROM programmer to access only the program storage area.*

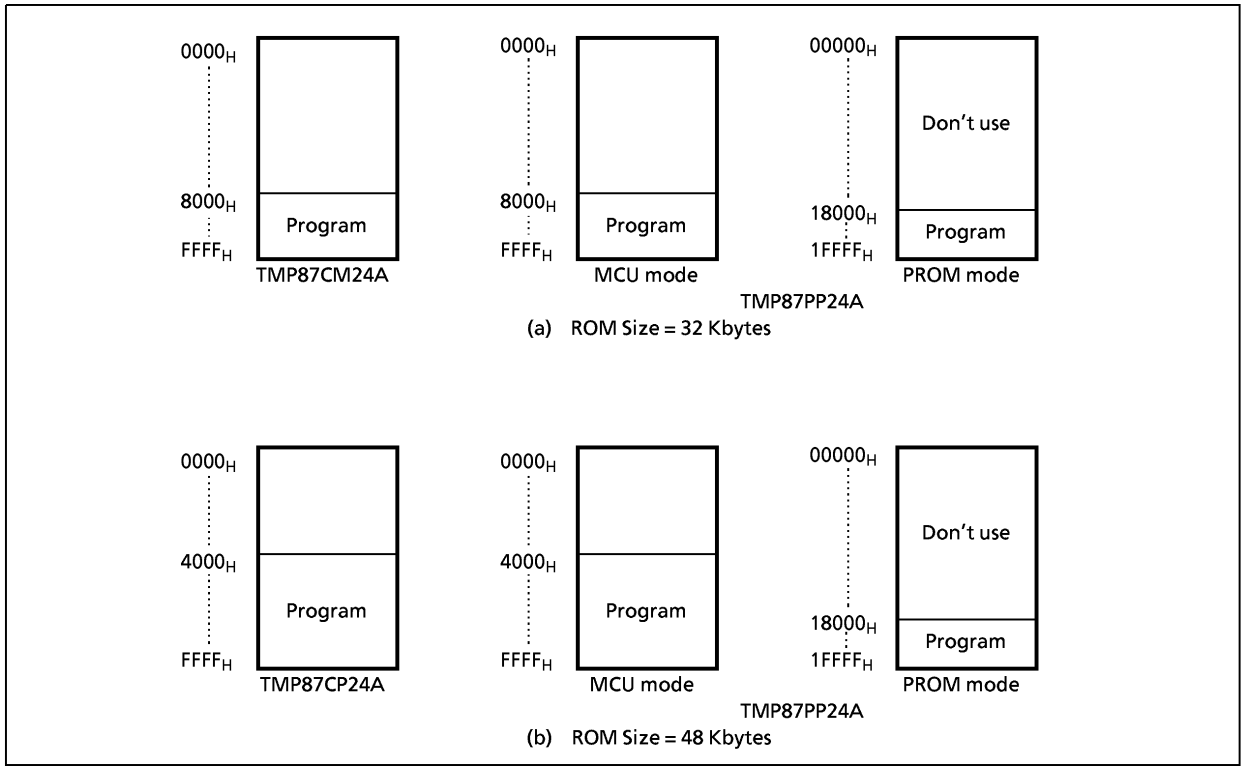


Figure 1-1. Program Memory Area

1.1.2 Data Memory

The TMP87PP24A 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 TMP87PP24A are the same as those of the TMP87CM24A/CP24A except that the TEST pin has no built-in pull-down resistance.

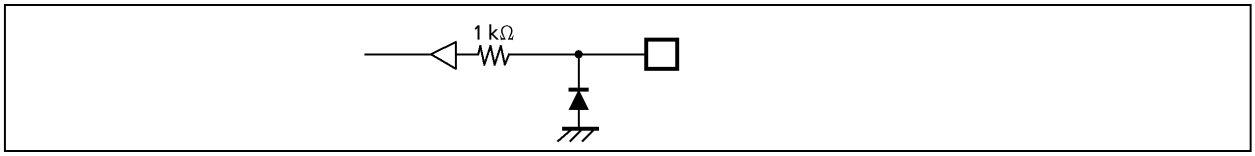


Figure 1-2. TEST Pin

(2) I/O ports

The I/O circuits of TMP87PP24A I/O ports the are the same as the those of TMP87CM24A/CP24A.

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 TMP87PP24A is not supported an electric signature mode, so the ROM type must be set to TC571000D.

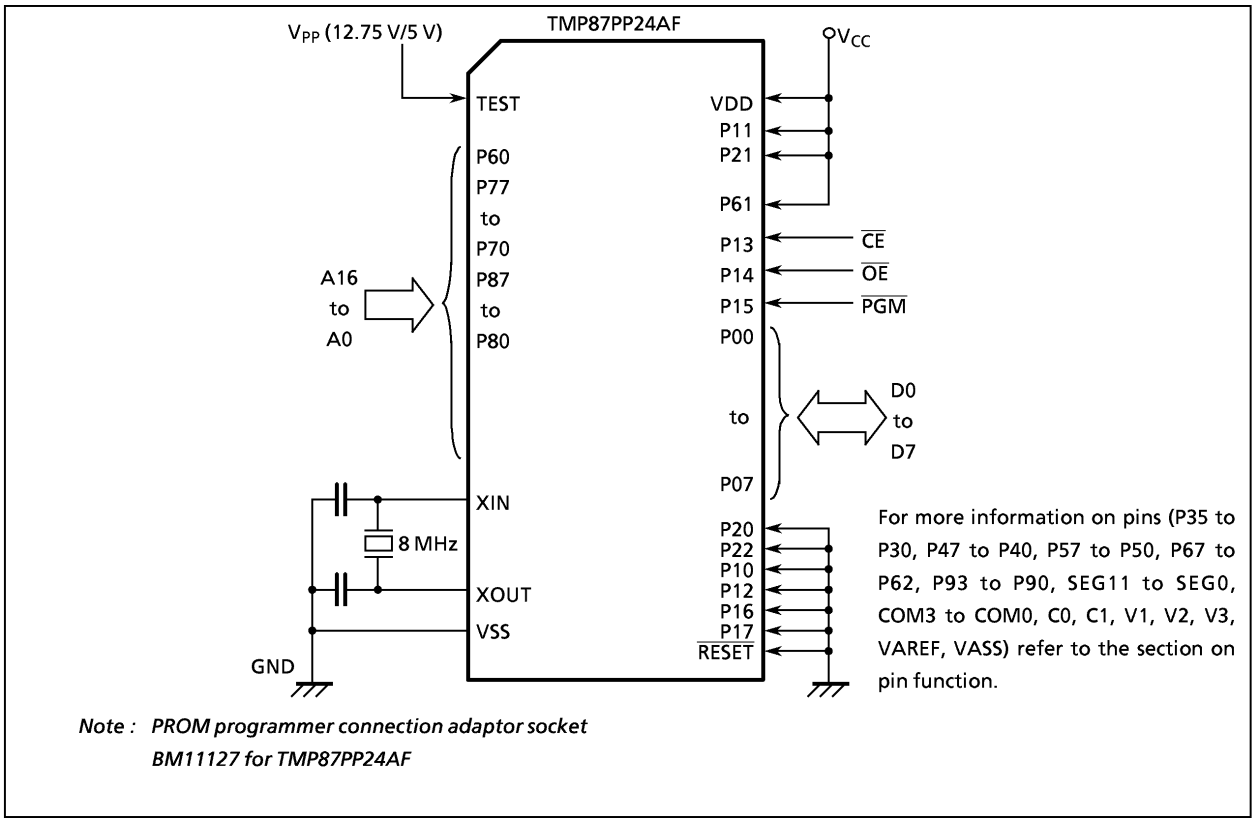


Figure 1-3. Setting for PROM Mode

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.

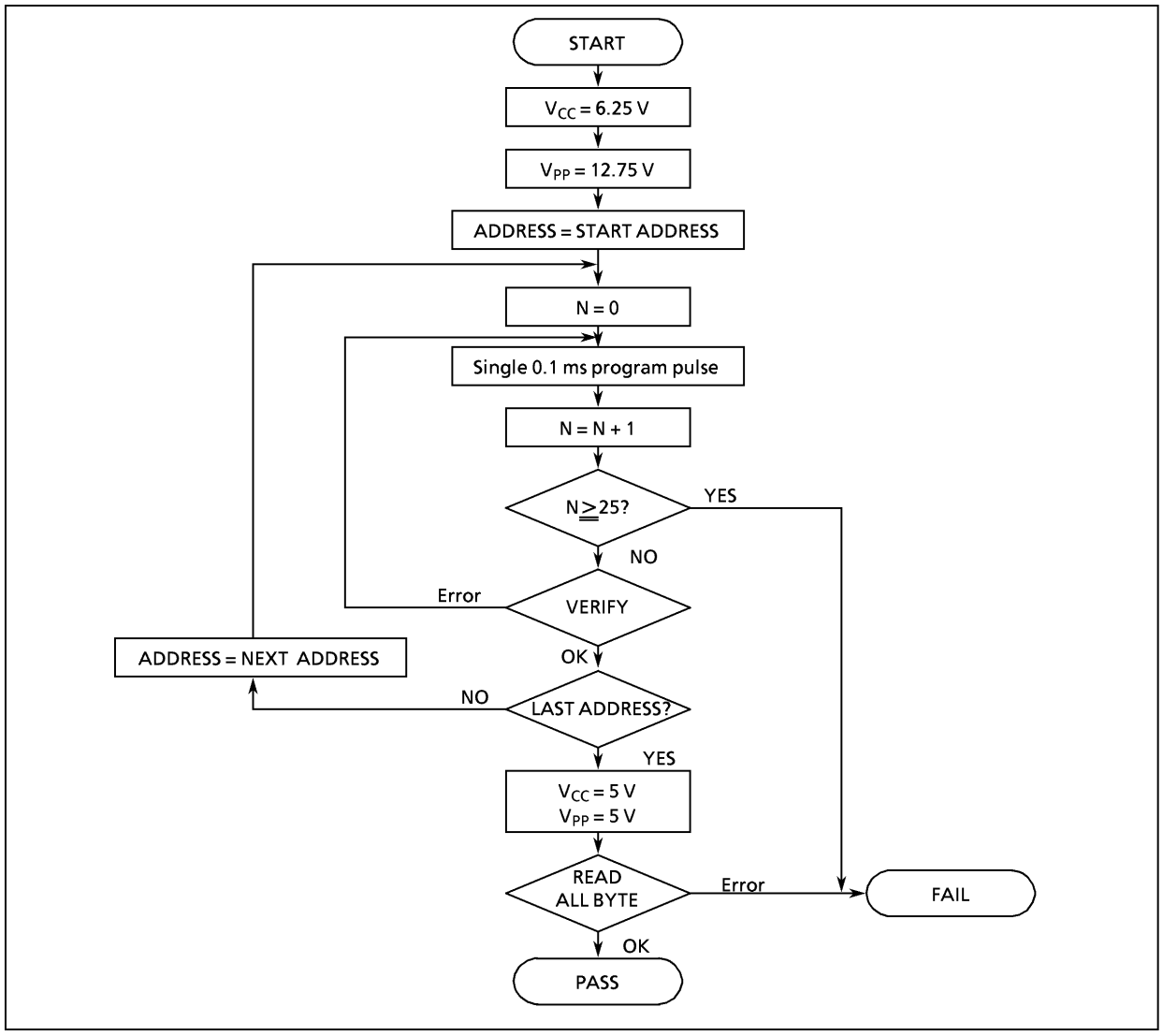


Figure 1-4. Flow Chart of High-speed Programming

1.2.2 Writing Method for General-purpose PROM Program

(1) Adapters
BM11127 : TMP87PP24AF

(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 TMP87PP24A, 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 TMP87PP24A 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.

Electrical Characteristics

Absolute Maximum Ratings (V_{SS} = 0 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	
	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)	ΣI_{OUT1}	Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41)	120	
	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	
Operating Temperature	Topr		– 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} = 0V, Topr = – 10 to 70°C)

Parameter	Symbol	Pins	Conditions		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	2.2		
				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_{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_{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} = 2.2 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 = – 10 to 70°C)

Parameter	Symbol	Pins	Conditions	Min	Typ.	Max	Unit
Hysteresis Voltage	V_{HS}	Hysteresis inputs		—	0.9	—	V
Input Current	I_{IN1}	TEST	V_{DD} = 5.5 V, 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 Resistance	R_{IN2}	$\overline{RESET}$		100	220	450	kΩ
Output Leakage Current	I_{LO1}	Open drain ports	V_{DD} = 5.5 V, V_{OUT} = 5.5 V	—	—	2	μA
	I_{LO2}	Tri-state ports	V_{OUT} = 5.5 V/0 V	—	—	± 2	
Segment/Common Output Voltage	V_{LCD1}	SEG39 to SEG0 and COM3 to COM0		0.75	1.0	1.33	V
	V_{LCD2}			V_{LCD1} × 2			
	V_{LCD3}			V_{LCD1} × 3			
Output High Voltage	V_{OH1}	Push-pull ports (P4 port)	V_{DD} = 4.5 V, I_{OH} = – 200 μA	2.4	—	—	
	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	
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	
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 Voltage boost frequency = 1 kHz	—	31	70	μA
Supply Current in SLEEP mode				—	16	40	
Supply Current in STOP mode			V_{DD} = 5.5 V V_{IN} = 5.3 V/0.2 V	—	0.5	10	

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: V_{LCD2} indicates an output voltage at the 2/3 level when operating in the 1/4 or 1/3 duty mode.
Note 5: V_{LCD1} 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 V, V_{DD} = 2.7 to 5.5 V, Topr = – 10 to 70°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 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.

AD Conversion Characteristics (II)

(V_{SS} = 0V, V_{DD} = 2.2 to 2.7V, Topr = – 10 to 70°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	$\triangle V_{AREF}$		2.2	–	–	
Analog Input Voltage	V_{AIN}		V_{ASS}	–	V_{AREF}	
Analog Supply Current	I_{REF}	V_{AREF} = 5.5 V, V_{ASS} = 0.0 V	–	0.5	1.0	mA
Nonlinearity Error		V_{DD} = 2.2 V, V_{SS} = 0.0 V V_{AREF} = 2.200 V V_{ASS} = 0.000 V	–	–	± 2	LSB
Zero Point Error			–	–	± 2	
Full Scale Error			–	–	± 2	
Total Error			–	–	± 4	

Note: Quantizing error is not contained in those errors.

AC Characteristics (I) (V_{SS} = 0V, V_{DD} = 4.5 to 5.5V, Topr = – 10 to 70°C)

Parameter	Symbol	Conditions	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}					

AC Characteristics (II) (V_{SS} = 0 V, V_{DD} = 2.2 to 5.5 V, Topr = – 10 to 70°C)

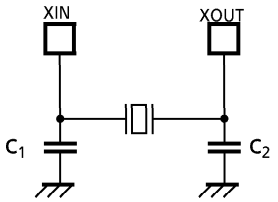
Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	t_{cy}	In NORMAL 1, 2 mode	0.95	–	10	μs
		In IDLE 1, 2 mode				
		In SLOW mode	117.6	–	133.3	
		In SLEEP mode				
High Level Clock Pulse Width	t_{WCH}	For external clock operation (XIN input), fc = 4.2 MHz	110	–	–	ns
Low Level Clock Pulse 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 (Ⅰ) (V_{SS} = 0 V, V_{DD} = 4.5 to 5.5 V, Topr = − 10 to 70°C)

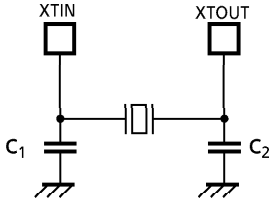
Parameter	Osillator	Frequency	Recommender Oscillator		Recommended Condition C_1	Recommended Condition C_2
High-frequency	Ceramic Resonator	8 MHz	KYOCERA	KBR8.0M	30pF	30pF
			Standard/Lead Type (MURATA)	CSA8.00MTZ CST8.00MTW	built-in 30pF	built-in 30pF
			Standard/SMP Type (MURATA)	CSAC8.00MT	30pF	30pF
			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 (Ⅱ) (V_{SS} = 0 V, V_{DD} = 2.2 to 5.5 V, Topr = − 10 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	CSA4.00MG	30pF	30pF
			(MURATA)	CST4.00MGW	built-in 30pF	built-in 30pF
			Standard/SMD Type (MURATA)	CSA4.00MGC CSAC4.00MGCM	30pF	30pF
				CSTC4.00MG	built-in 30pF	built-in 30pF
			Standard/Small Chip Type	CSTCS4.00MG	built-in 10pF	built-in 10pF



(1) High-frequency



(2) Low-frequency

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.

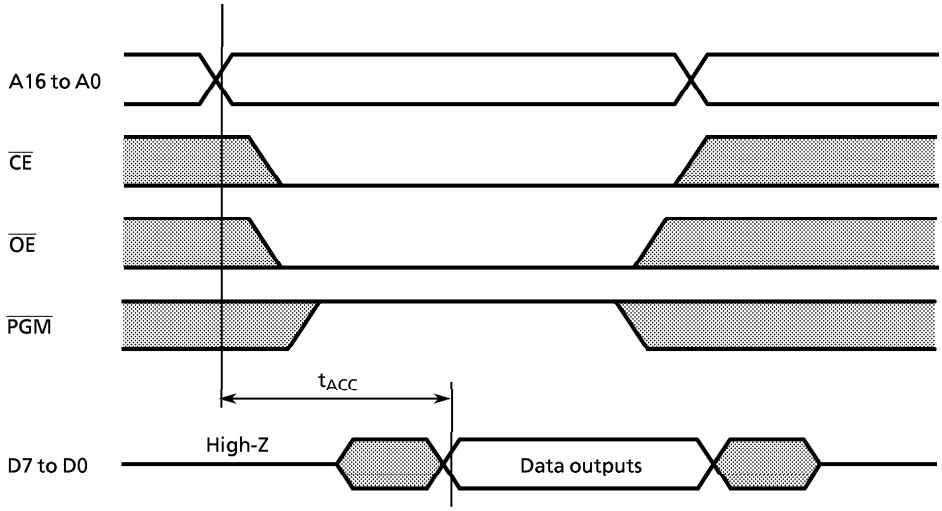
Note2: The product numbers and specifications of the resonators by Murata Manufacturing Co., Ltd. are subject to change. For up-to-date information, please refer to the following URL; http://www.murata.co.jp/search/index.html

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

(1) Read Operation

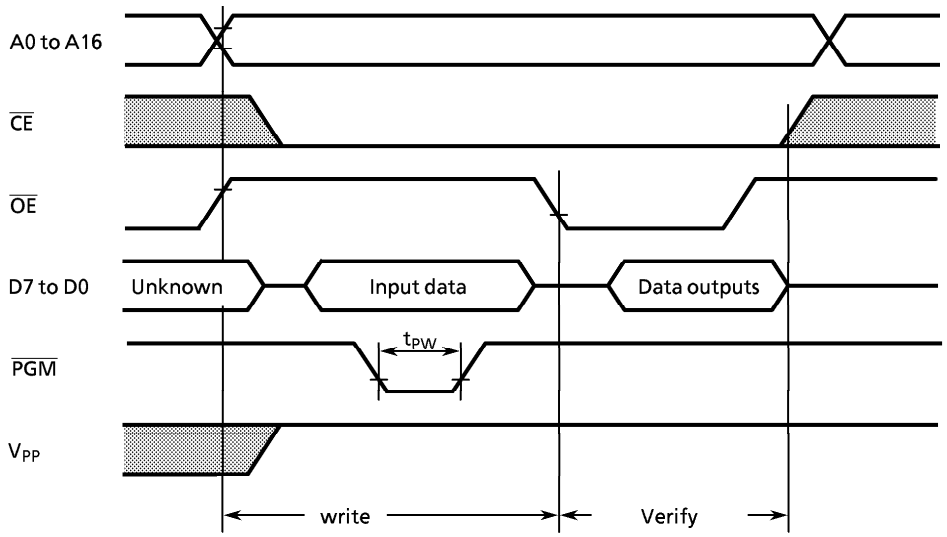
Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Input High Voltage	V_{IH4}		$V_{CC} \times 0.7$	–	V_{CC}	V
Input Low Voltage	V_{IL4}		0	–	$V_{CC} \times 0.12$	
Power Supply Voltage	V_{CC}		4.75	5.0	5.25	
Program Power Supply Voltage	V_{PP}					
Address Access Time	t_{ACC}	V_{CC} = 5.0 ± 0.25V	–	1.5tcyc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

Note: tcyc = 500 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 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.