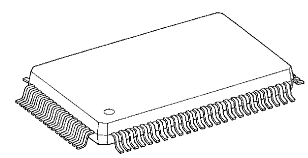
CMOS 8-Bit Microcontroller

TMP87PP21F
TMP87PP21DF

The TMP87PP21 is a One-Time PROM microcontroller with low-power 48 K × 8 bits electrically programmable read only memory for the TMP87CH21C/M21C/P21C system evaluation. The TMP87PP21 is pin compatible with the TMP87CH21C/M21C/P21C. The operations possible with the TMP87CH21C/M21C/P21C can be performed by writing programs to PROM. The TMP87PP21 can write and verify in the same way as the TC571000D using an adaptor socket BM11104/BM11105 and an EPROM programmer.

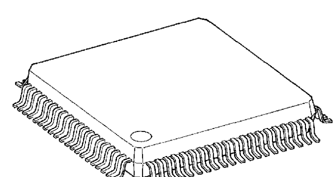
Product No.	OTP	RAM	Package	OTP Adapter
TMP87PP21F	48 K × 8 bits	2 K × 8 bits	P-QFP80-1420-0.80B	BM11104
TMP87PP21DF			P-LQFP80-1212-0.50A	BM11105

P-QFP80-1420-0.80B



TMP87PP21F

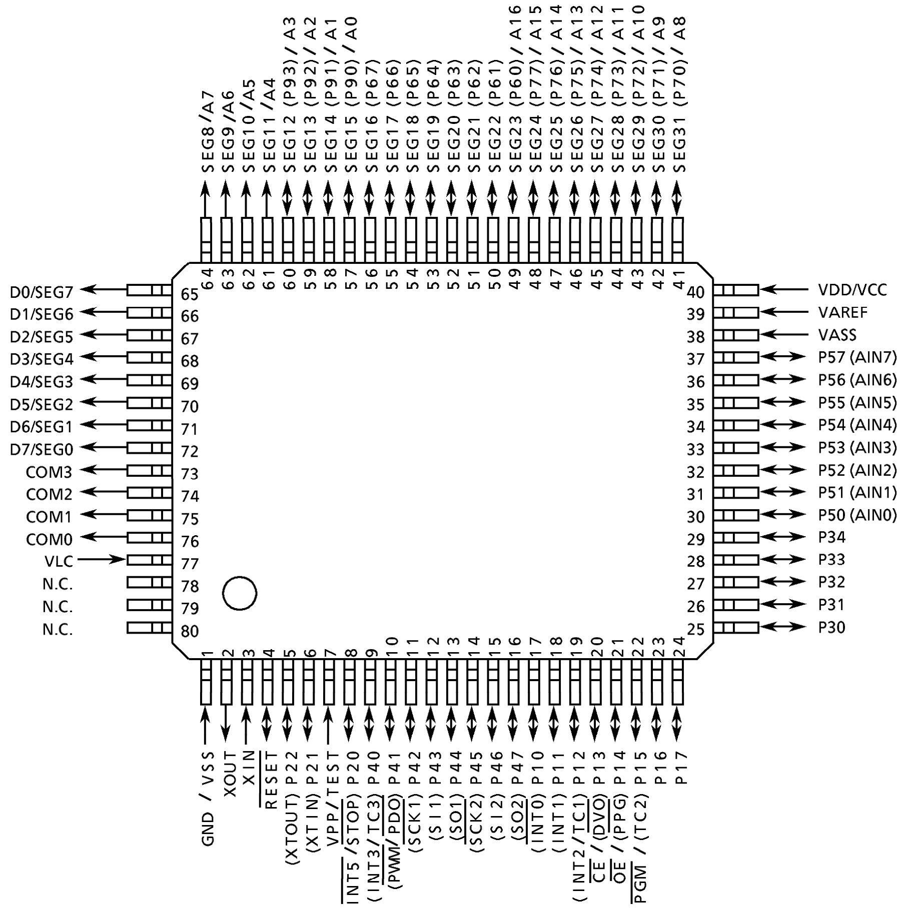
P-LQFP80-1212-0.50A



TMP87PP21DF

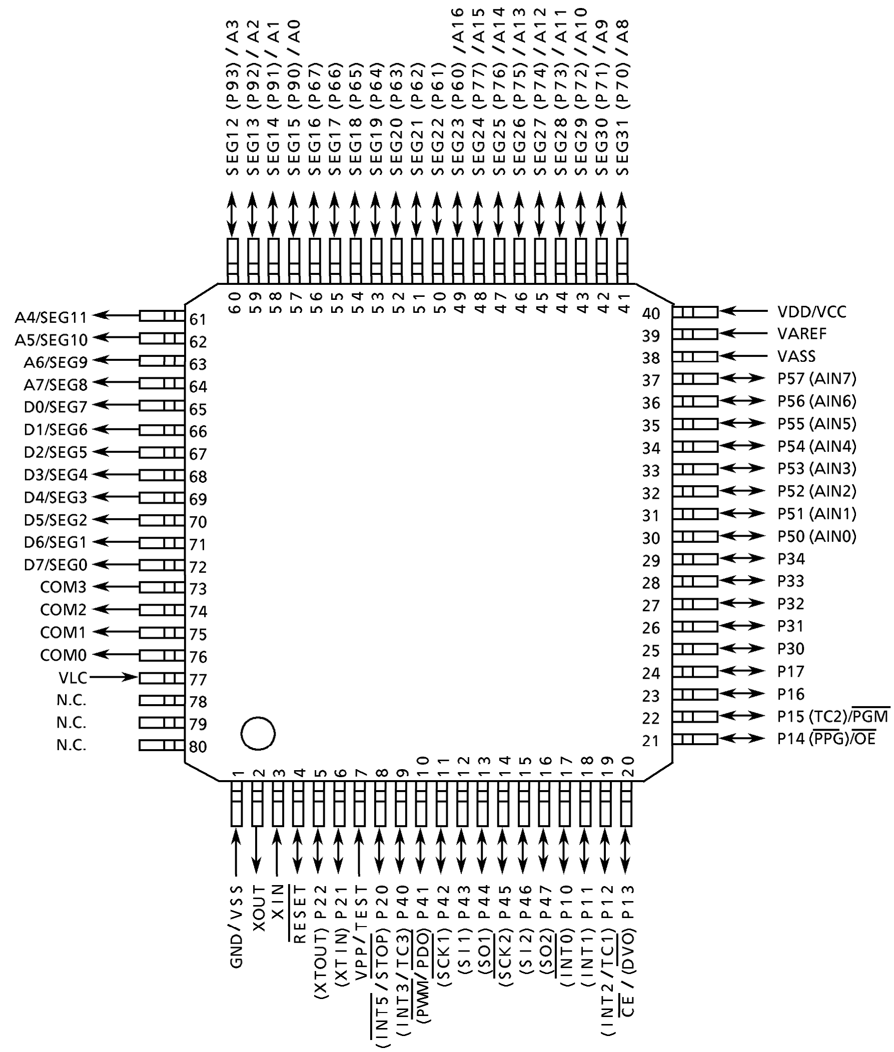
Pin Assignments (Top View)

P-QFP80-1420-0.80B



Note: Always keep N.C. pins open.

P-LQFP80-1212-0.50A



Note: Always keep N.C. pins open.

Pin Functions

The TMP87PP21 has two modes: MCU and PROM.

(1) MCU mode

In this mode, the TMP87PP21 is pin compatible with the TMP87CH21C/M21C/P21C (fix the TEST pin at low level.)

(2) PROM mode

Pin Name (PROM mode)	Input/Output	Functions	Pin Name (MCU mode)
A16	Input	PROM address inputs	P60
A15 to A8			P77 to P70
A7 to A0			SEG8 to 11, P93 to P90
D7 to D0	I/O	PROM data input/outputs	SEG0 to SEG7
$\overline{CE}$	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
P37 to P32, P30	I/O	Pull-up with resistance for input processing.	
P47 to P40			
P57 to P50			
P67 to P62			
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	
VLC	LCD driver Power supply		

Operational Description

The following explains the TMP87PP21 hardware configuration and operation. The configuration and functions of the TMP87PP21 are the same as those of the TMP87CH21C/M21C/P21C, except in that a one-time PROM is used instead of an on-chip mask ROM.
The TMP87PP21 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 TMP87PP21 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 TMP87CH21C/M21C/P21C (the TEST/VPP pin cannot be used open because it has no built-in pull-down resistance).

1.1.1 Program Memory

The TMP87PP21 has a 48K × 8 bits (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 TMP87PP21 is used as a system evaluation of the TMP87CH21C/M21C/P21C, the data is written to the program storage area shown in Figure 1-1.

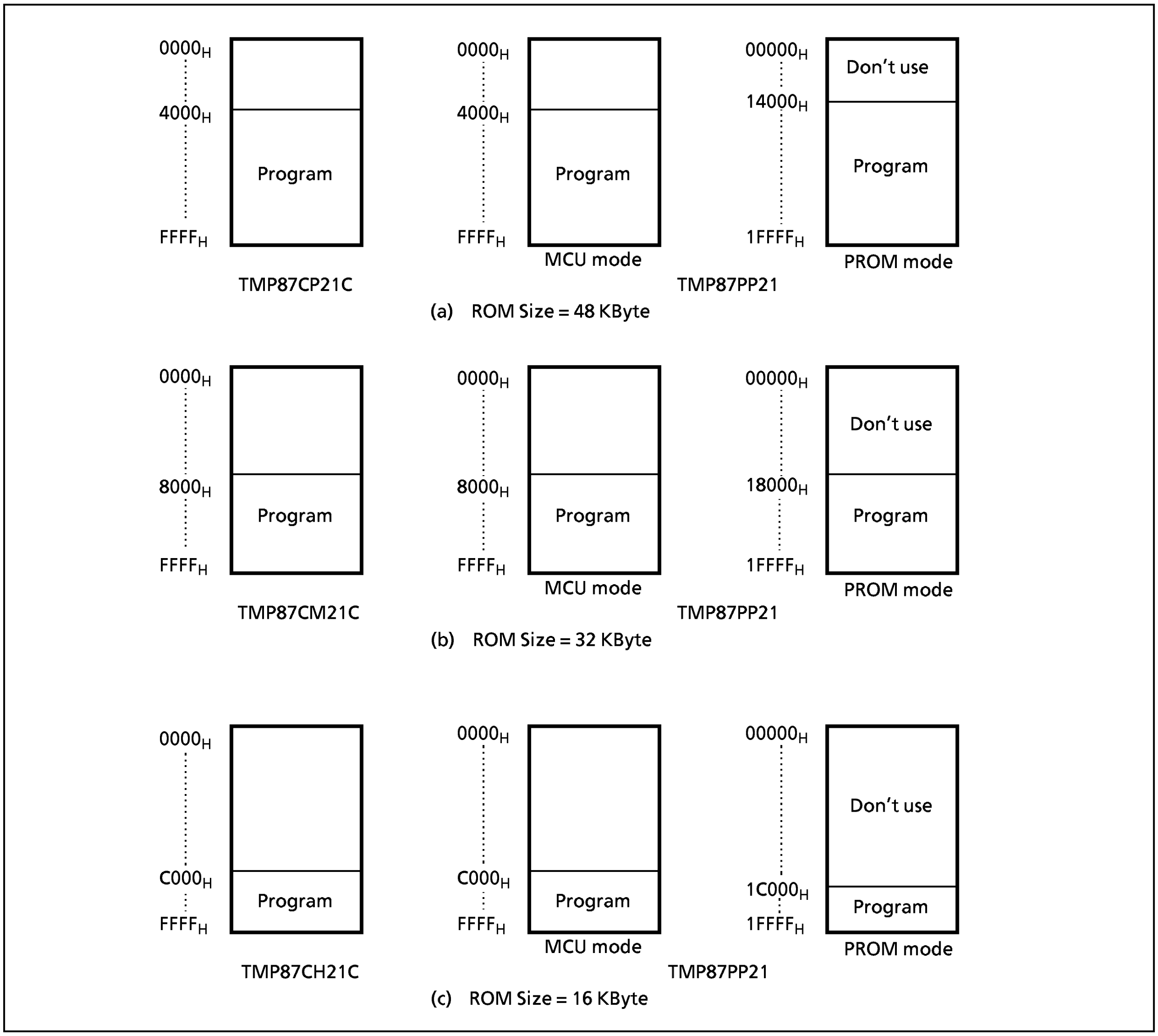


Figure 1-1. Program Storage Area

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 TMP87PP21 has an on-chip 2 K × 8 bits data memory (static RAM).

1.1.3 Input/Output Circuitry

(1) Control pins

The control pins of the TMP87PP21 are the same as those of the TMP87CH21C/M21C/P21C except that the TEST pin has no built-in pull-down resistance.

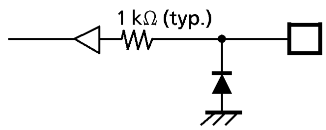


Figure 1-2. TEST pin

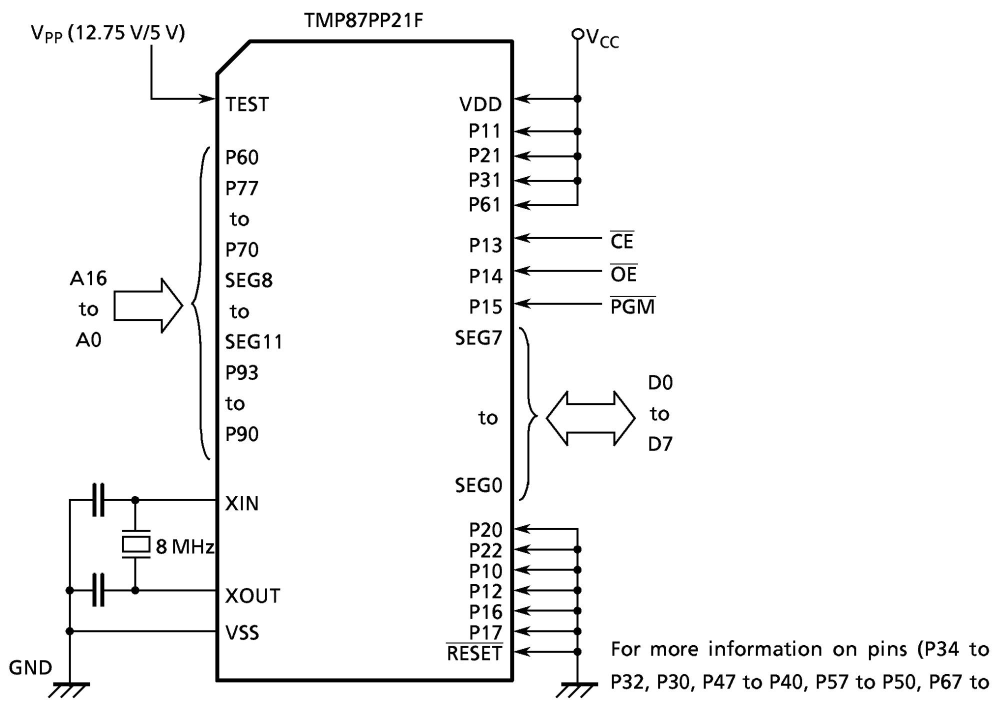
(2) I/O ports

The I/O circuitries of the TMP87PP21 I/O ports are the same as circuitries of the TMP87CH21C/M21C/P21C.

1.2 PROM Mode

The PROM mode is activated by setting the TEST, $\overline{RESET}$ pin and the ports P17 to P10, P22 to P20 and P31, 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. (Please set the high-speed programming mode according to each manual of PROM programmer.)*
> *The TMP87PP21 is not supported an electric signature mode, so the ROM type must be set to TC571000D.*



Note: PROM programmer connection adaptor socket
BM11104 for TMP87PP21F
BM11105 for TMP87PP21DF

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 $\overline{PGM}$ 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.

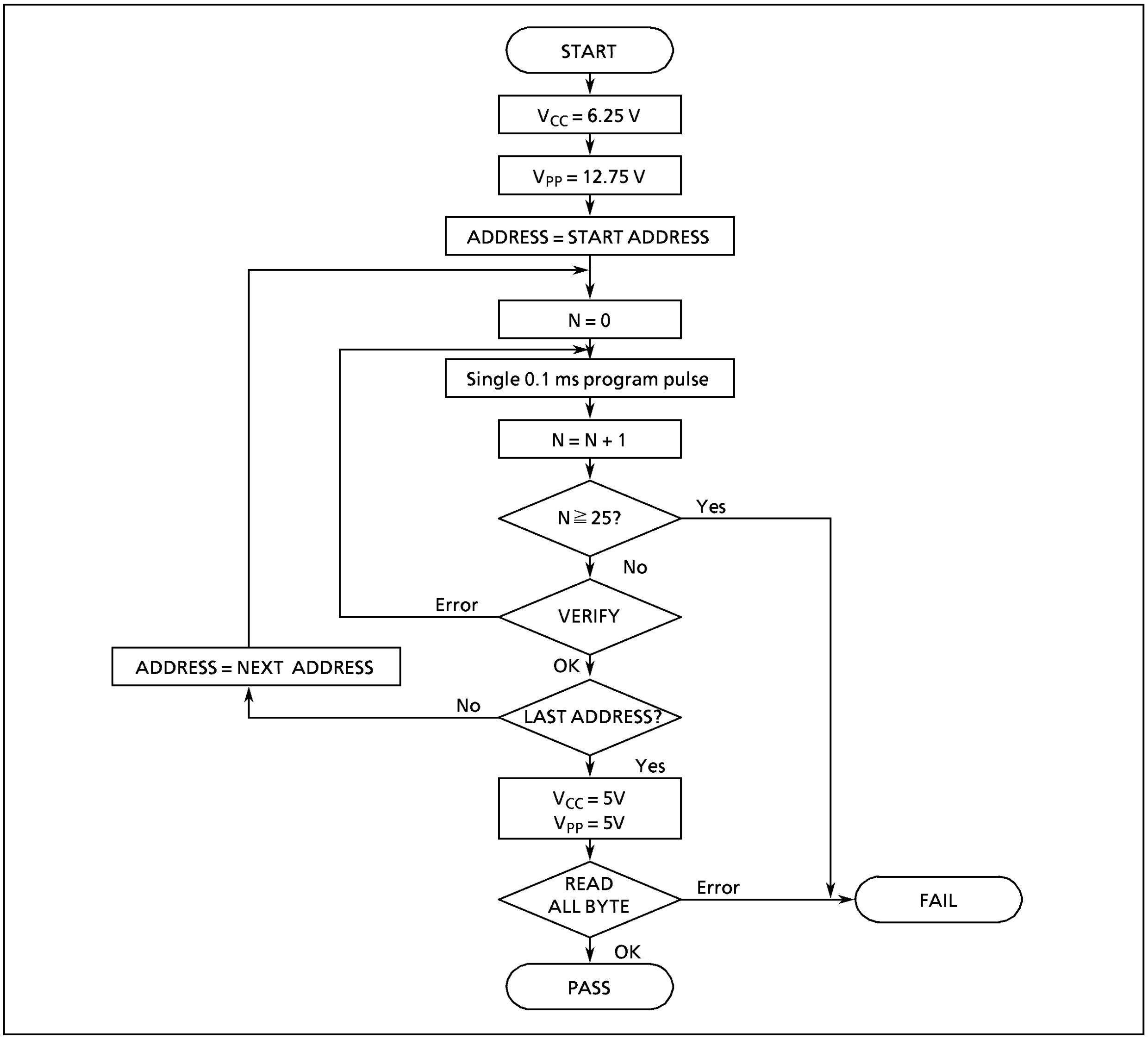


Figure 1-4. Flowchart of High-speed Programming

1.2.2 Writing Method for General-purpose PROM Program

(1) Adapters
BM11104: TMP87PP21F
BM11105: TMP87PP21DF

(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 TMP87PP21, 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 48 KB: 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 TMP87PP21 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 ± 0.5 V 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	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	mA
Output Current (Total)	ΣI_{OUT1}	Ports P0, P1, P2, P3, P5, P6, P7, P8, P9, P4 (except P41)	120	mA
	ΣI_{OUT2}	P41	30	mA
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

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 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	2.7		
				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	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_{LO}	Open drain ports Tri-state ports	V_{DD} = 5.5 V, V_{OUT} = 5.5 V	–	–	2	μA
Output High Voltage	V_{OH1}	Push-pull ports P4 ports	V_{DD} = 4.5 V, I_{OH} = – 200 μA	2.4	–	–	V
	V_{OH2}	Tri- state ports 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 LCD driver is not enable	–	30	60	μA
Supply Current in SLEEP mode				–	15	30	
Supply Current in STOP mode			V_{DD} = 5.5 V V_{IN} = 5.3 V/0.2 V	–	0.5	10	
Segment Output Low Resistance	R_{OS1}	SEG31 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}	SEG31 to SEG0		–	200	–	
Common Output High Resistance	R_{OC2}	COM3 to COM0					
Segment/Common Output Voltage	$V_{O\ 2/3}$	SEG31 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	

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 Roc1/2.
Note 9: Times for SEG/COM output switching on: Ros1, Roc1: 2^6/fc, 2/fs (s)
Ros2, Roc2: 1/(n, f_F)
(1/n: duty, f_F: frame frequency)

AD Conversion Characteristics

(V_{SS} = 0 V, V_{DD} = 2.7 to 5.5 V, Topr = – 30 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	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.

AC Characteristics - 1

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

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Machine Cycle Time	t_{cy}	In NORMAL 1, 2 mode	0.5	–	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	62.5	–	–	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 - 2

(V_{SS} = 0 V, V_{DD} = 2.7 to 5.5 V, Topr = – 30 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-1

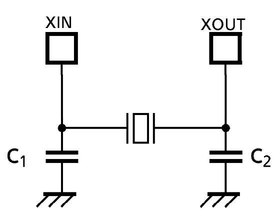
(VSS = 0 V, VDD = 4.5 to 5.5 V, Topr = – 30 to 70°C)

Parameter	Osillator	Frequency	Recommender Oscillator		Recommended Condition	
					C_1	C_2
High-frequency	Ceramic Resonator	8 MHz	KYOCERA	KBR8.0M	30 pF	30 pF
			Standard/Lead Type (MURATA)	CSA8.00MTZ	30 pF	30 pF
				CST8.00MTW	built-in 30 pF	built-in 30 pF
			Standard/SMP Type (MURATA)	CSAC8.00MT	30 pF	30 pF
			Standard/Small ChipType (MURATA)	CSTC8.00MT	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

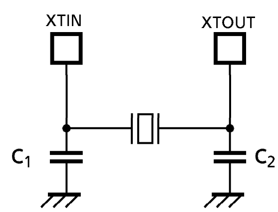
Recomended Oscillating Condition-2

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

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

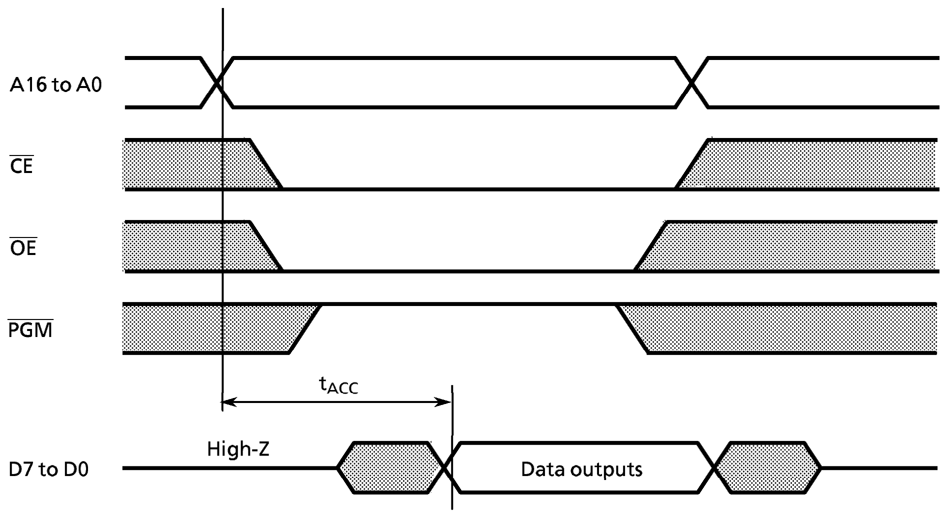
DC/AC Characteristics (PROM mode)

(V_{SS} = 0 V)

(1) Read Operation

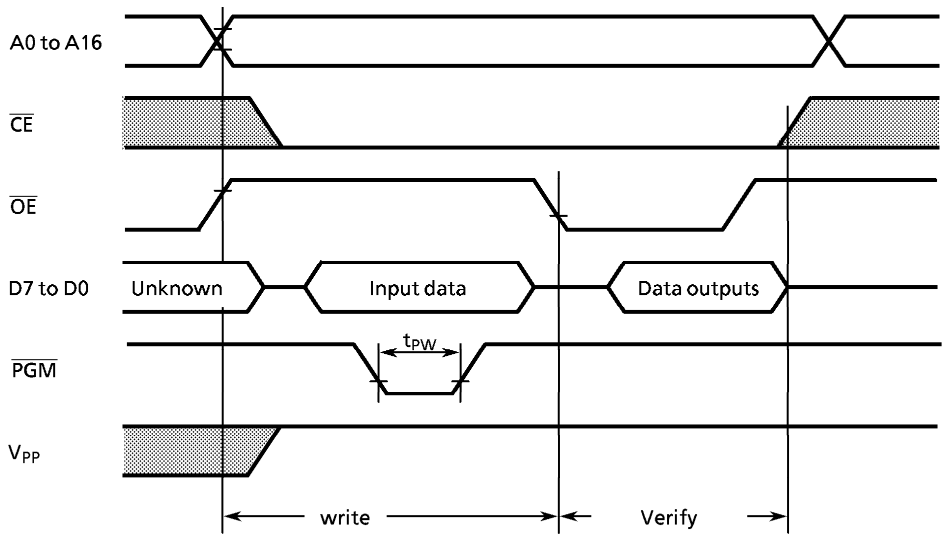
Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Input High Voltage	V_{IH4}		$V_{CC} \times 0.7$	–	V_{CC}	V
Input Low Voltage	V_{IL4}		0	–	$V_{CC} \times 0.12$	V
Power Supply Voltage	V_{CC}		4.75	5.0	5.25	V
Program Power Supply Voltage	V_{PP}		4.75	5.0	5.25	V
Address Access Time	t_{ACC}	$V_{CC} = 5.0 \pm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

Note: tcyc = 500 ns at 8 MHz



(2) High-Speed Programming 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	–	$V_{CC} \times 0.12$	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



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 op from it under applying the program voltage (12.75 V ± 0.25 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.