TOSHIBA

TOSHIBA Original CMOS 8-Bit Microcontroller

TLCS-870 Series

TMP87P809NG
TMP87P809MG

TOSHIBA CORPORATION

Semiconductor Company

Important Notices

Thank you for your continued patronage of Toshiba microcontrollers.

This page gives you important information on using Toshiba microcontrollers. Please be sure to check each item for proper use of our products.

TOSHIBA Microcontrollers
870 Family
(TMP87C409BN) (TMP87C409BM) (TMP87C809BN) (TMP87C809BM) (TMP87P809)

Datasheet Modifications: I²C Bus Mode Control

The following problem is included in the explanation of the I²C bus function of this data sheet.
It will guide the correction as follows. Please read it for the explanation of this data sheet as follows.

Section: "I²C Bus Mode Control"

- **In the explanation of the Serial Bus Interface Control Register 1**
  1. Delete the setting examples where the serial clock frequency exceeds 100 kHz.
  2. Add the following note.

SCK	Serial clock selection	000 : Reserved (Note) 001 : Reserved (Note) 010 : 58.8 kHz 011 : 30.3 kHz 100 : 15.4 kHz 101 : 7.75 kHz 110 : 3.89 kHz 111 : reserved	at fc = 8MHz (Output on SCL pin)	Write-only

Note: This I²C bus circuit does not support the Fast mode. It supports the Standard mode only. Although the I²C bus circuit itself allows the setting of a baud rate over 100 kbps, the compliance with the I²C specification is not guaranteed in that case.

- **In "(3) Serial clock"**
  1. Add the following sentence about the communication baud rate.

a. Clock source

The SCK (bits 2 to 0 in the SBICR1) is used to select a maximum transfer frequency outputted on the SCL pin in the master mode. Set a communication baud rate that meets the I²C bus specification, such as the shortest pulse width of t_{LOW}, based on the equations shown below.

In both master mode and slave mode, a pulse width of at least 4 machine cycles is require for both "H" and "L" levels.

$t_{LOW} = 2^n/f_c$

$t_{HIGH} = 2^n/f_c + 8/f_c$

$fscl = 1/(t_{Low} + t_{HIGH})$

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
TMP87P809N	P-SDIP28-400-1.78	TMP87P809NG	SDIP28-P-400-1.78	—
TMP87P809M	P-SOP28-450-1.27	TMP87P809MG	SOP28-P-450-1.27B	—

*: 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

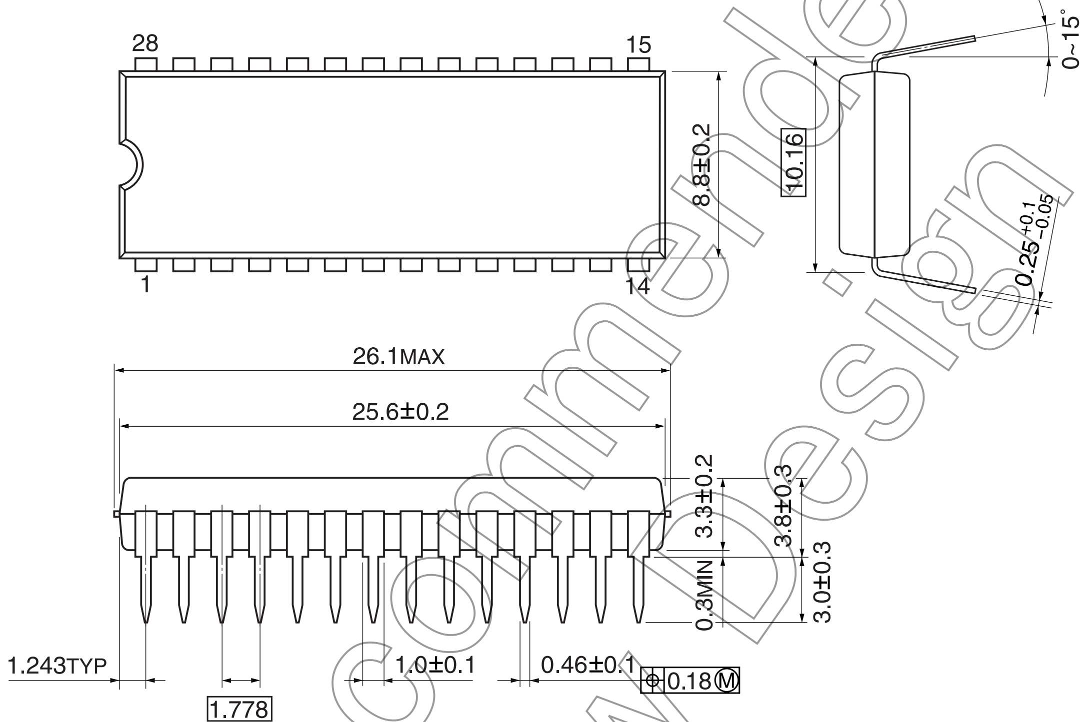
The publication date of this datasheet is printed at the lower right corner of this notification.

(Annex)

Package Dimensions

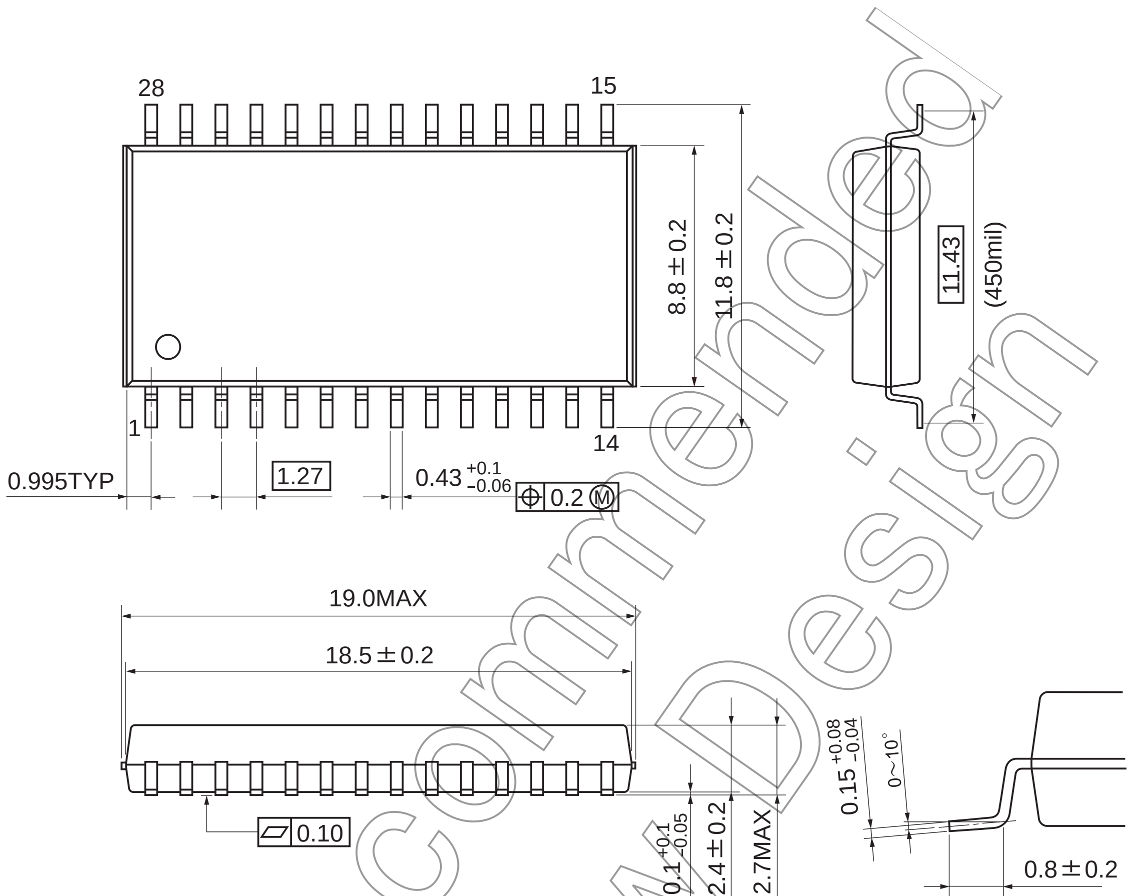
SDIP28-P-400-1.78

Unit: mm



SOP28-P-450-1.27B

Unit: mm



Note: Palladium plated

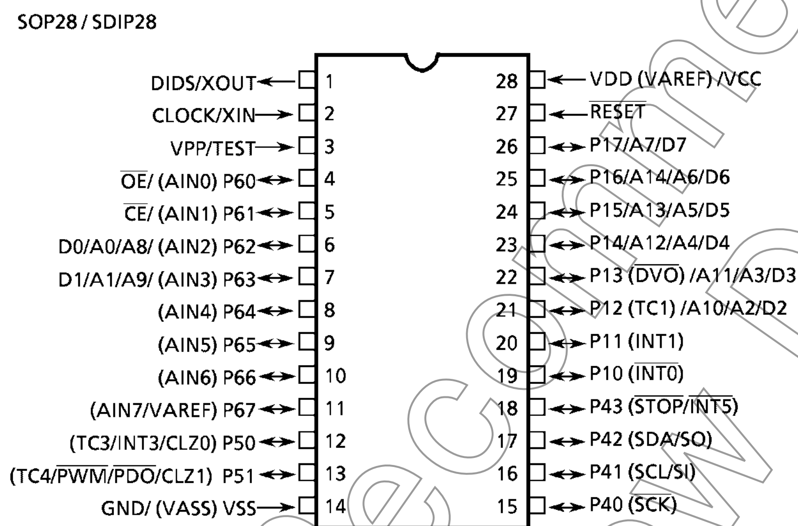
CMOS 8-bit Microcontroller

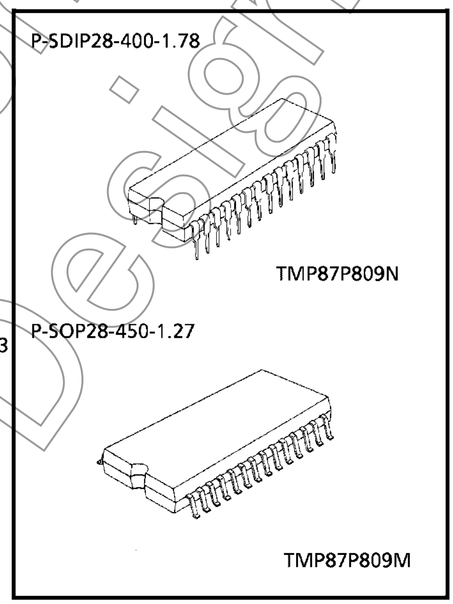
TMP87P809N/M

The TMP87P809 is a high-speed, high-performance 8-bit single chip microcomputer, which has 64-Kbits One-Time PROM. The TMP87P809 is pin compatible with the TMP87C409B/809B. The operations possible with the TMP87C409B/809B can be performed by writing programs to PROM. The TMP87P809 can write and verify in the same way as the TC57256AD using an adapter socket and a general-purpose PROM programmer.

Poduct No.	ROM	RAM	Package	Adapter socket
TMP87P809N	8 Kbytes	256 bytes	P-SDIP28-400-1.78	BM11122
TMP87P809M			P-SOP28-450-1.27	BM11116

Pin Assignments (Top View)





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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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Pin Function

The TMP87P809 has two modes: MCU and PROM.

(1) MCU mode

In this mode, the TMP87P809 is pin compatible with the TMP87C409B/809B (fix the TEST pin at "L" level).

(2) PROM mode

Pin Name (PROM mode)	Input / Output	Functions	Pin name (MCU mode)
A14 to A8	Input	Program memory address input	P17 to P12, P63, P62
A7 to A0			P17 to P12, P63, P62
D7 to D0	I/O	Program memory data input/output	P17 to P12, P63, P62
$\overline{CE}$	Input	Chip enable signal input	P61
$\overline{OE}$		Output enable signal input	P60
VPP	Power supply	+ 12.5 V / 5 V (Program supply voltage)	TEST
VCC		+ 5 V	VDD
GND		0 V	VSS
P11 to P10	I/O	PROM mode setting pins. Be fixed at "L" level.	
P43 to P40			
P51 to P50			
P67 to P64			
$\overline{RESET}$	Input		
XIN	Input	Inputs a clock externally. (CLOCK)	XIN
XOUT	Input	PROM mode control signal (DIDS) input	XOUT

Operational Description

The configuration and function of the TMP87P809 are the same as those of the TMP87C409B/809B, except in that a one-time PROM is used instead of an on-chip mask ROM.

1. Operating Mode

The TMP87P809 has two modes: MCU and PROM.

1.1 MCU Mode

The MCU mode is activated by fixing the TEST/VPP pin at "L" level.

In the MCU mode, operation is the same as with the TMP87C409B/809B (TEST/VPP pin cannot be used open because it has no built in pull-down resistance.)

1.1.1 Program memory

The TMP87P809 has a 8 Kbyte (addresses E000 to $FFFF_H$ in the MCU mode, addresses 6000 to $7FFF_H$ in the PROM mode) one-time PROM.

To use the TMP87P809 as the system evaluation for the TMP87C409B/809B, the program should be written to the program memory area as shown in Figure 1-1.

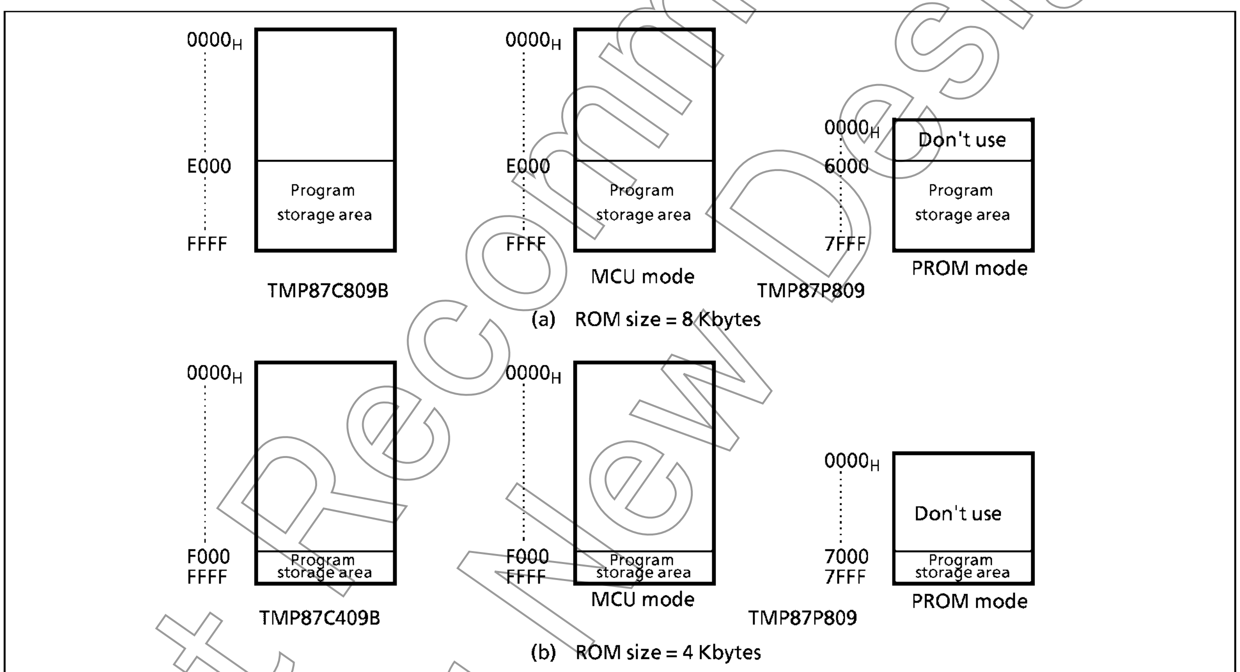


Figure 1-1. Program memory area

Note: Either write the data FFH to the unused area or set the general-purpose PROM programmer to access only the program storage area

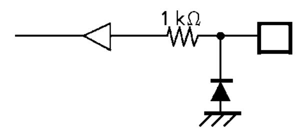
1.1.2 Data memory

The TMP87P809 has an 256 bytes data memory (static RAM).

1.1.3 Input / Output circuits

(1) Control pins

The control pins of the TMP87P809 are the same as those of the TMP87C409B/809B except that the TEST pin has no built-in pull-down resistance.



Note: TEST pin has no built-in pull-down resistance

Figure 1-2. TEST Pin

(2) I/O port

The I/O circuits of TMP87P809 ports are the same as the TMP87C409B/809B.

1.2 PROM Mode

The PROM mode is used to write and verify programs with a general-purpose PROM programmer.

Note: Please set the high-speed programming mode according to each manual of PROM programmer.

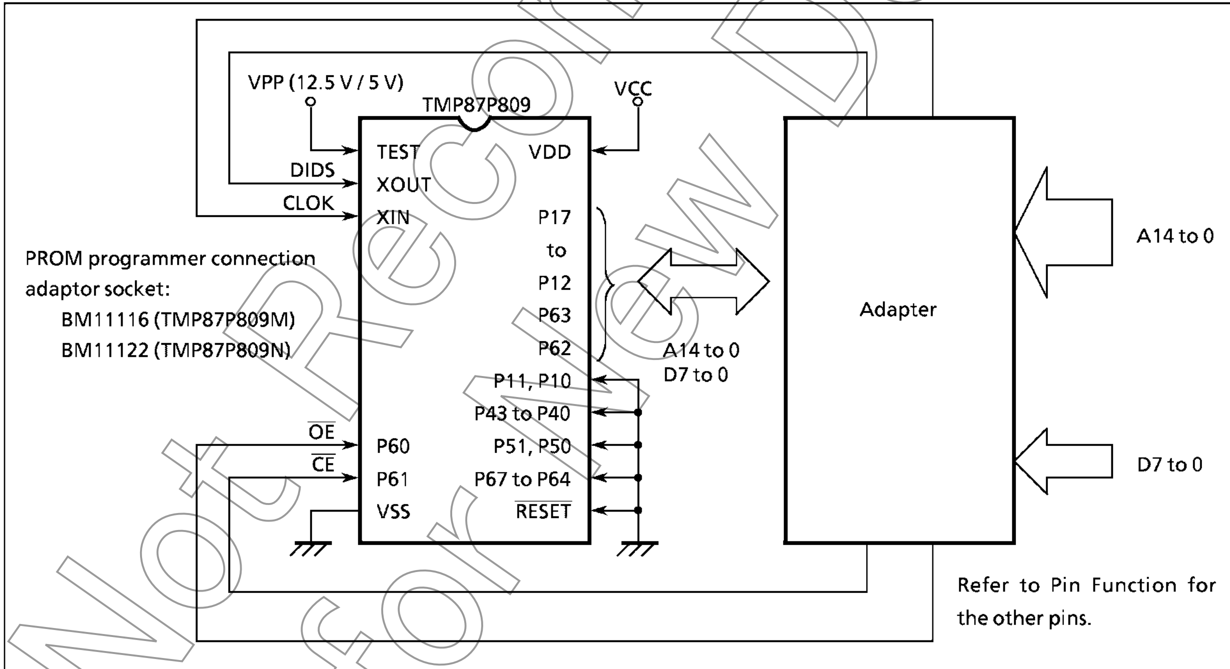


Figure 1-3. Setting for PROM mode

1.2.1 Programming flowchart (High-speed Programming Mode-I)

The high-speed programming mode is achieved by applying the program voltage (+ 12.5 V) to the Vpp pin when Vcc = 6 V. After the address and input data are stable, the data is programmed by applying a single 1ms program pulse to the $\overline{CE}$ input. The programmed data is verified. If incorrect, another 1ms program pulse is applied and then the programmed data is verified. This process should be repeated (up to 25 times) until the program operates correctly. Programming for one address is ended by applying additional program pulse with width 3 times that needed for initial programming (number of programmed times × 1 ms). 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.

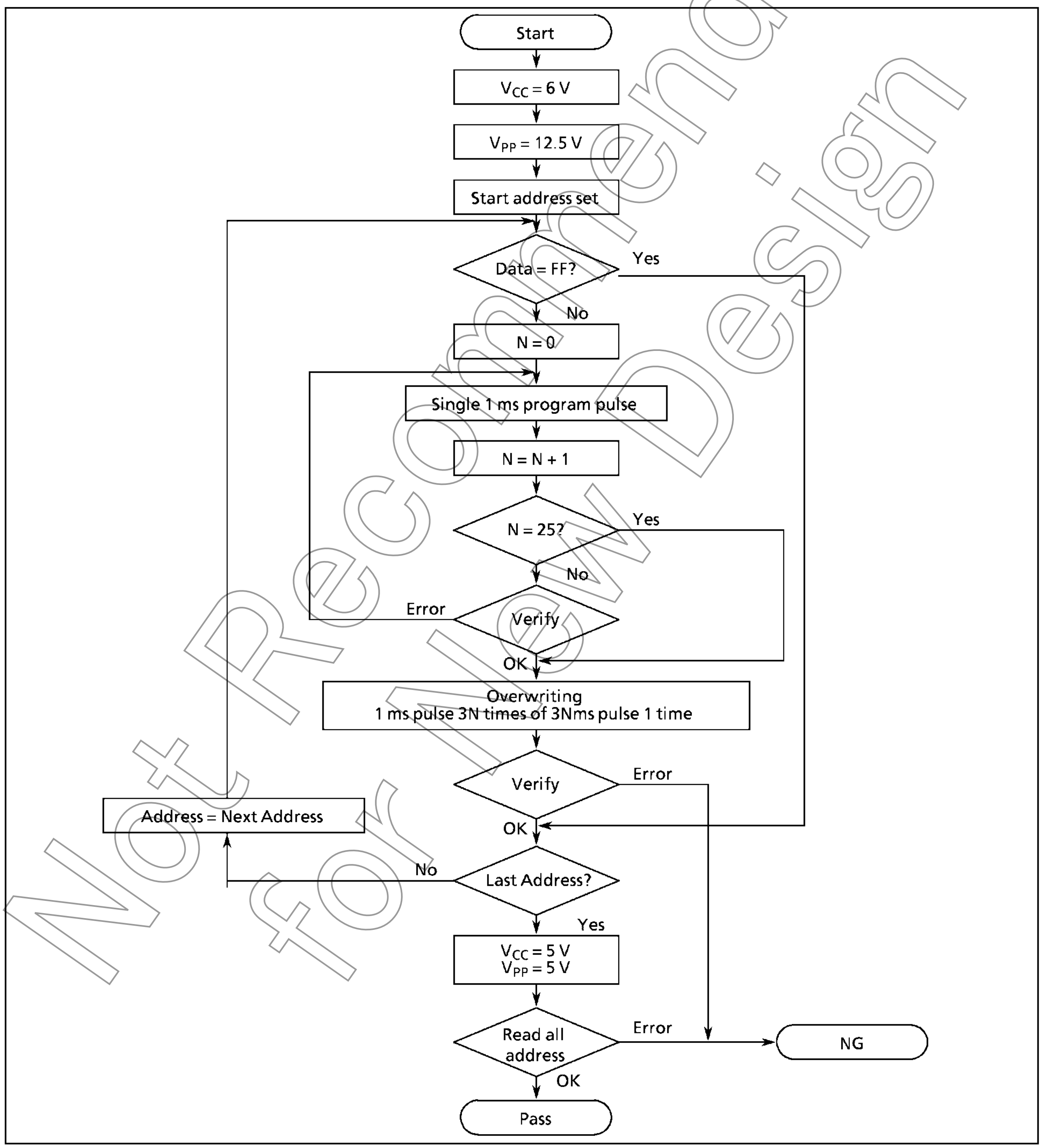


Figure 1-4. Flowchart of high-speed programming mode - I

1.2.2 Programming flowchart (High-speed Programming Mode-II)

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 $\overline{CE}$ input. The programmed data is verified. If incorrect, another 0.1ms program pulse is applied and then the programmed data is verified. 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.

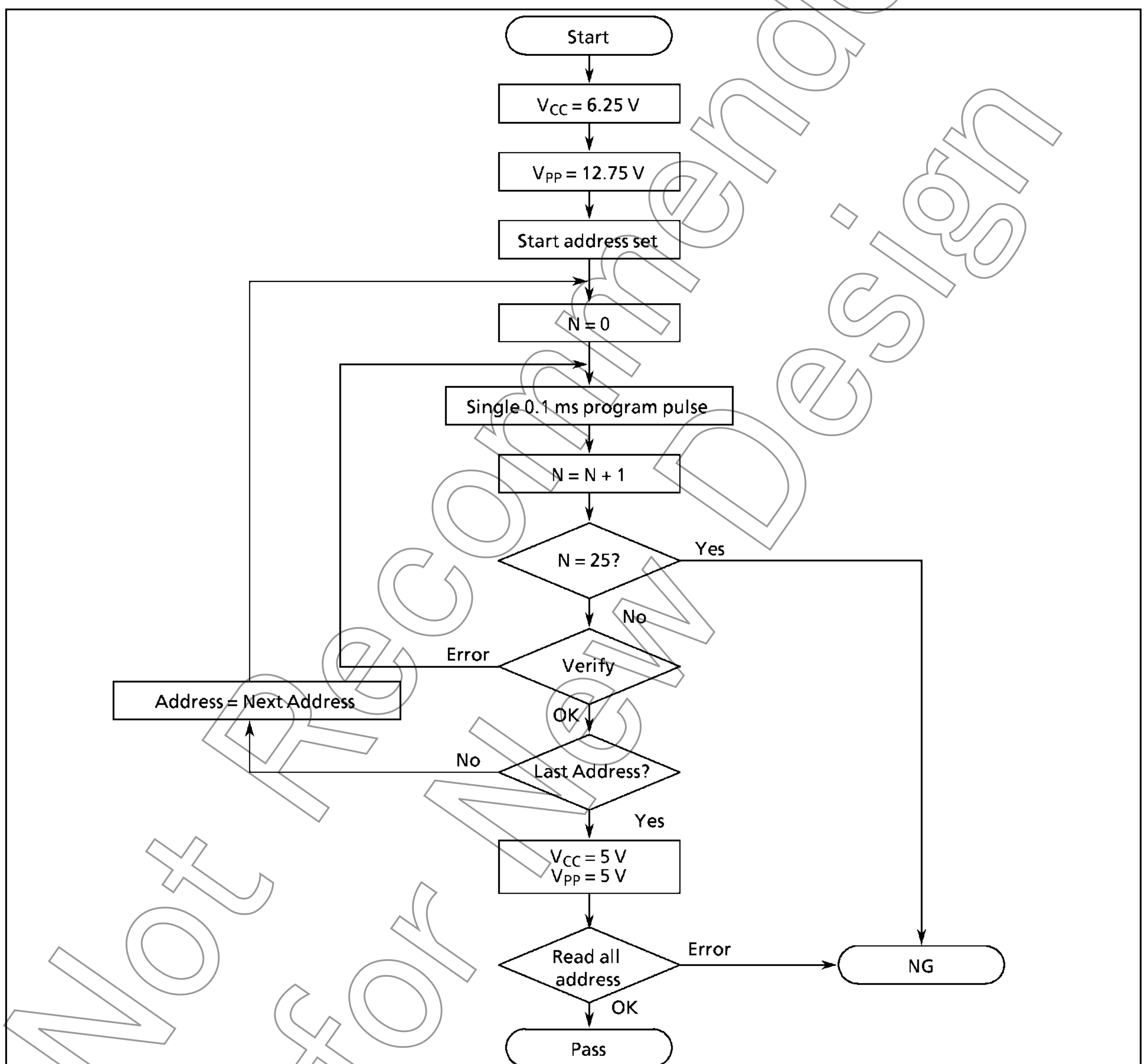


Figure 1-5. Flowchart of high-speed programming mode - II

1.2.3 Writing method for general-purpose PROM program

(1) Adapters
BM11116: TMP87P809M
BM11122: TMP87P809N

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

(3) PROM programmer specifying

i) PROM type is specified to TC57256AD.
Writing voltage: 12.5 V (high-speed program I mode)
12.75 V (high-speed program II mode)

ii) Data transfer (copy) (note 1)
In TMP87P809, EPROM is within the addresses 6000 to $7FFF_H$. 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 4KB: transferred addresses F000 to $FFFF_H$ to addresses 7000 to $7FFF_H$
ROM capacity of 8KB: transferred addresses E000 to $FFFF_H$ to addresses 6000 to $7FFF_H$

iii) Writing address is specified. (note 1)
Start address: 7000_H (ROM 8 KB: 6000_H)
End address: $7FFF_H$

(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. The data in addresses 0000 to $5FFF_H$ must be specified to FF_H.

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: TMP87P809 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	Condition		Ratings	Unit
Supply Voltage		V_{DD}			− 0.3 to 6.5	V
Program Voltage		V_{PP}	TEST/V_{PP} pin		− 0.3 to 13.0	V
Input Voltage		V_{IN}			− 0.3 to V_{DD} + 0.3	V
Output Voltage		V_{OUT1}	Ports P1, P5, P6, XOUT		− 0.3 to V_{DD} + 0.3	V
		V_{OUT2}	Port P4		− 0.3 to 5.5	
Output Current (Per 1 pin)	IOL	I_{OUT1}	Ports P1, P6		3.2	mA
		I_{OUT2}	Ports P4, P5		30	
	IOH	I_{OUT3}	Ports P1, P5, P6		− 1.8	
Output Current (Total)	IOL	ΣI_{OUT1}	Ports P1, P6		30	mA
		ΣI_{OUT2}	Ports P4, P5		80	
	IOH	ΣI_{OUT3}	Ports P1, P5, P6		30	
Power Dissipation [Topr = 70°C]		PD		SDIP	300	mW
				SOP	180	
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	NORMAL mode	4.5	5.5	V
				IDLE mode			
			fc = 4.2 MHz	NORMAL mode	2.2		
				IDLE 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	VDD = 4.5 to 5.5 V		1.0	8.0	MHz
			V_{DD} = 2.2 V to 5.5 V			4.2	

Note1: 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.

Note2: Clock frequency fc: Supply voltage range is specified in NORMAL mode and IDLE 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 input		–	0.9	–	V
Input Current	I_{IN1}	TEST	V_{DD} = 5.5 V V_{IN} = 5.5 V / 0 V	–	–	± 2	μA
	I_{IN2}	Tri-state ports					
	I_{IN3}	$\overline{RESET}$, $\overline{STOP}$					
Input Resistance	R_{IN2}	$\overline{RESET}$		100	220	450	kΩ
Output Leakage Current	I_{LO}	Tri-state ports	V_{DD} = 5.5 V, V_{OUT} = 5.5 V / 0 V	– 2	–	2	μA
Output High Voltage	V_{OH2}	Tri-state ports	V_{DD} = 4.5 V, I_{OH} = – 0.7 mA	4.1	–	–	V
Output Low Voltage	V_{OL1}	Except XOUT, P4 and P5	V_{DD} = 4.5 V, I_{OL} = 1.6 mA	–	–	0.4	V
Output Low current	I_{OL3}	P4, P5	V_{DD} = 4.5 V, V_{OL} = 1.0 V	–	20	–	mA
Supply Current in NORMAL modes	I_{DD}		V_{DD} = 5.5 V fc = 8 MHz V_{IN} = 5.3 V / 0.2 V		8	14	mA
Supply Current in IDLE modes					4	6	
Supply Current in NORAML mode			V_{DD} = 3.0 V fc = 4.2 MHz V_{IN} = 2.8 V / 0.2 V		2.5	3.5	mA
Supply Current in IDLE mode					1.5	2.0	
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 IIN1, IIN3,: The current through resistor is not included, when the input resistor (pull-up or pull-down) is contained.

AD Conversion Characteristics

(V_{SS} = 0 V, V_{DD} = 2.2 to 5.5V, Topr = – 30 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 range	V_{AIN}		V_{ASS}	–	V_{AREF}	V
Analog Reference Current	I_{REF}	V_{AREF} = 5.5 V, V_{ASS} (V_{SS}) = 0.0 V	–	0.5	1.0	mA
Nonlinearity Error		V_{DD} = 5.0 V V_{AREF} = 5.000 V V_{ASS} (V_{SS}) = 0.000 V or V_{DD} = 2.2 V V_{AREF} = 2.200 V V_{ASS} (V_{SS}) = 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.

Oscillation Stop Detector Characteristics (V_{SS} = 0 V, Topr = – 30 to 70°C)

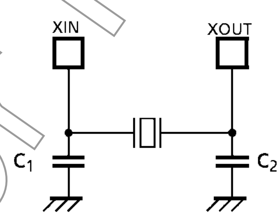
Parameter	SYMBOL	Conditions	Min	Typ.	Max	Unit
Detection time	T_{CLZ}	VDD = 2.2 V to 5.5V (fc = 2 MHz to 4.2 MHz) VDD = 4.5 V to 5.5 (fc = 8 MHz)	2	20	400	μs

AC Characteristics (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	tcy	In NORMAL mode In IDLE mode	0.5	–	4	μs
High Level Clock Pulse Width	t_{WCH}	For external clock operation	50	–	–	ns
Low Level Clock Pulse Width	t_{WCL}	fc = 8 MHz				

Recommended Oscillating Conditions (V_{SS} = 0 V, V_{DD} = 2.2 to 5.5 V, Topr = –30 to 70°C)

Parameter	Oscillator	Oscillation Frequency	Recommended Oscillator	Recommended Constant	
				C_1	C_2
High-frequency Oscillation	Ceramic Resonator	8 MHz (4.5 V to 5.5 V)	MURATA CST8.00MTW	—	
			MURATA CSA8.00MTZ	30 pF	30 pF
		4 MHz (2.2 V to 5.5 V)	MURATA CST4.00MGWU	—	
			MURATA CSA4.00MGU	30 pF	30 pF



(1) High-frequency Oscillation

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.

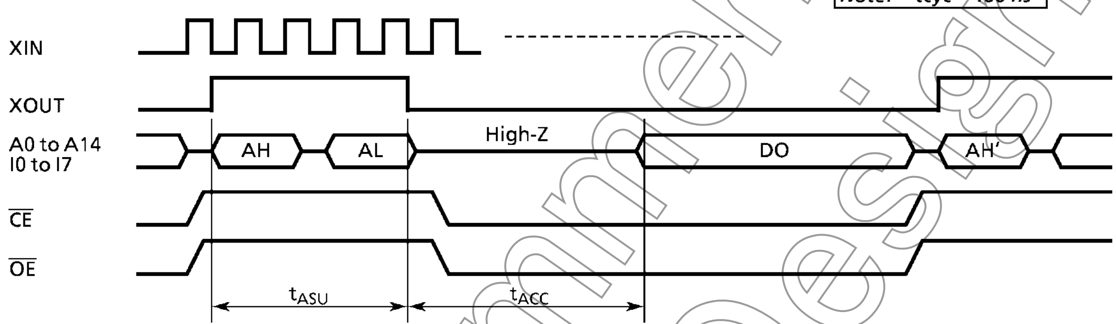
Note 2: The product numbers and specifications of the resonators by Murata Manufacturing Co., Ltd. are subject to change. For up-to-date information, please refer to the following URL;http://www.murata.com/

(1) READ OPERATION (T_{opr} = 0 to 70°C)

DC Characteristics, AC Characteristics (V_{SS} = 0 V)

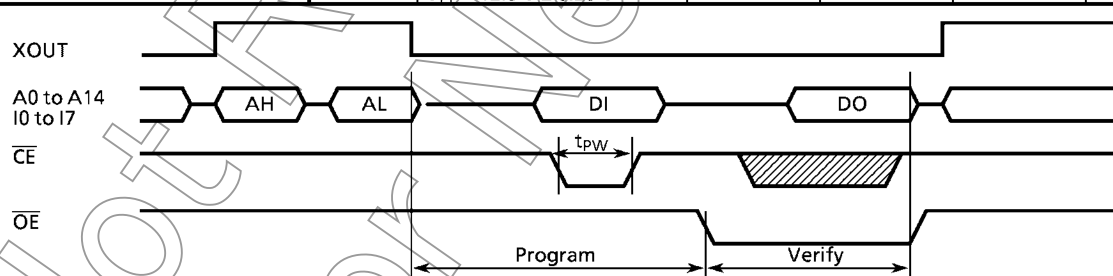
Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Input High Voltage	V_{IH4}		$V_{CC} \times 0.67$	–	V_{CC}	V
Input Low Voltage	V_{IL4}		0	–	$V_{CC} \times 0.3$	V
Supply Voltage	V_{CC}		4.75	5.00	5.25	V
Program Supply Voltage	V_{PP}		$V_{CC} - 0.6$	V_{CC}	$V_{CC+0.6}$	
Address Set-up Time	t_{ASU}		400	–	–	ns
Address Access Time	t_{ACC}	V_{CC} = 5.0 ± 0.25 V	–	5tcyc	–	ns

Note: tcyc = 400 ns



(2) Program Operation (High speed write mode - Ⅰ) (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	–	$V_{CC} \times 0.12$	V
Supply Voltage	V_{CC}		5.75	6.0	6.25	V
Program Supply Voltage	V_{PP}		12.0	12.5	13.0	V
Initial Program Pulse Width	t_{PW}	V_{CC} = 6.0 V ± 0.25 V, V_{PP} = 12.5 V ± 0.25 V	0.95	1.0	1.05	ms



Note: DO ; Data output (I0 to I7) AL ; Address input (A0 to A7)
DI ; Data input (I0 to I7) AH ; Address input (A8 to A14)

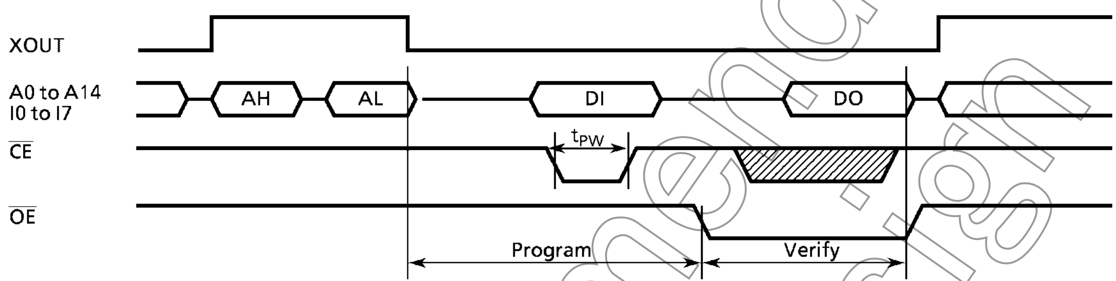
Note1: When V_{cc} power supply is turned on or after, V_{pp} must be increased.
When V_{cc} power supply is turned off or before, V_{pp} must be decreased.

Note2: The device must not be set to the EPROM programmer or picked up from it under applying the program voltage (12.5 V ± 0.5 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.

(3) Program Operation (High speed write mode - II) (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	–	$V_{CC} \times 0.12$	V
Supply Voltage	V_{CC}		6.00	6.25	6.50	V
Program Supply Voltage	V_{PP}		12.50	12.75	13.0	V
Initial Program Pulse Width	t_{PW}	V_{CC} = 6.25 V ± 0.25 V, V_{PP} = 12.75 V ± 0.25 V	0.095	0.1	0.105	ms



Note: DO ; Data output (I0 to I7) AL ; Address input (A0 to A7)
DI ; Data input (I0 to I7) AH ; Address input (A8 to A14)

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 decreased.
Note2: The device must not be set to the EPROM programmer or picked up from it under applying the program voltage (12.5 V ± 0.5 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.