Low Voltage/Low Power

CMOS 16-Bit Microcontrollers

TMP93PW40DF

1. Outline and Device Characteristics

The TMP93PW40 is OTP type MCU which includes 128-Kbyte One-time PROM. Using the adapter-socket, you can write and verify the data for TMP93PW40.TMP93PW40 has the same pin-assignment with TMP93CW40 (Mask ROM type) .

Writing the program to built-in PROM, the TMP93PW40 operates as the same way with TMP93CW40.

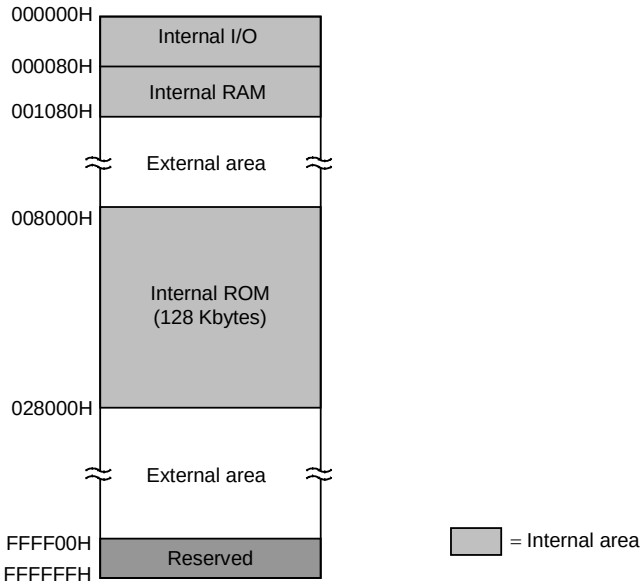


Figure 1.1 Memory Map of TMP93CW40/PW40

MCU	ROM	RAM	Package	Adapter Socket
TMP93PW40DF	OTP 128 Kbytes	4 Kbytes	P-LQFP100-1414-0.50F	BM11129

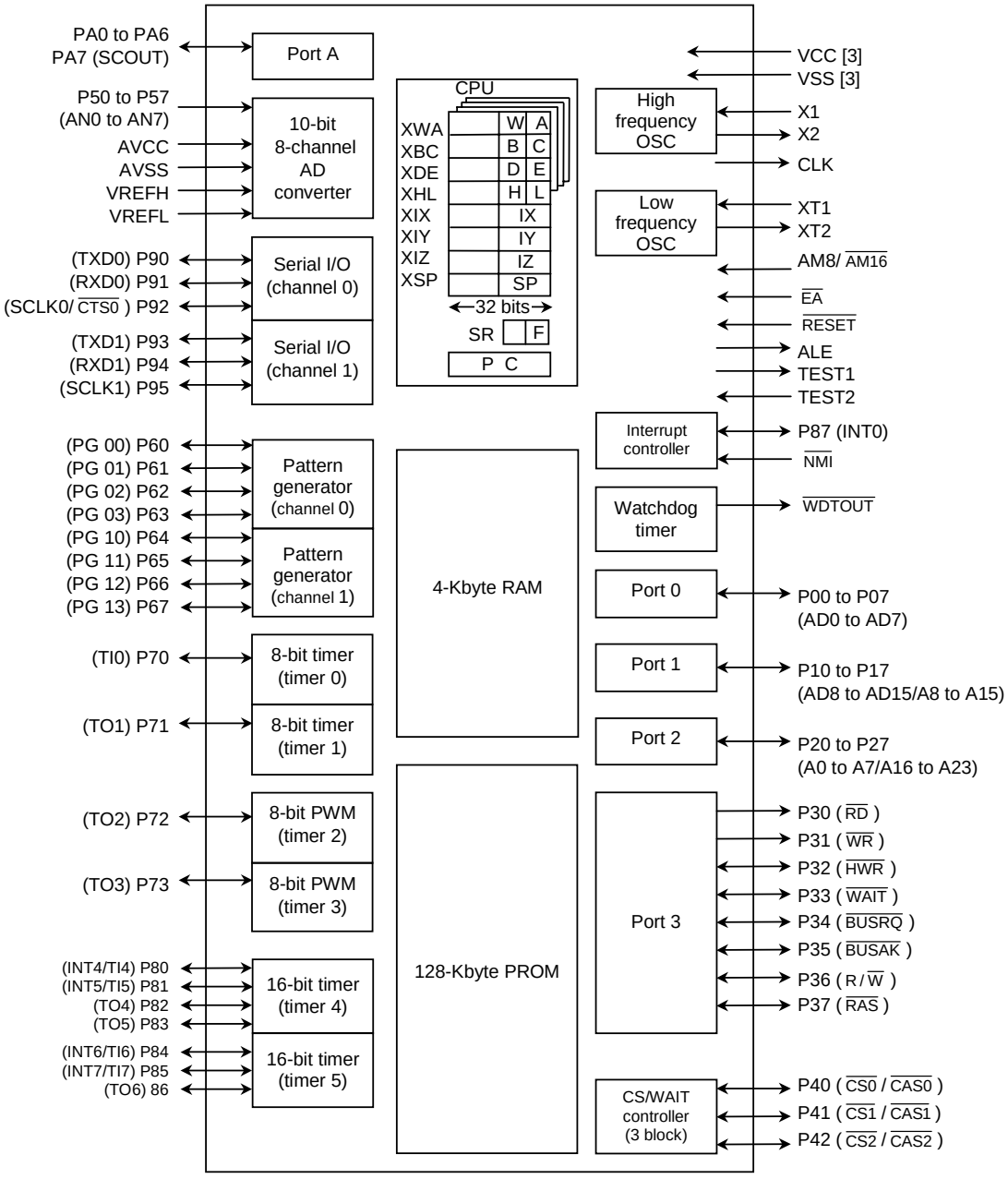


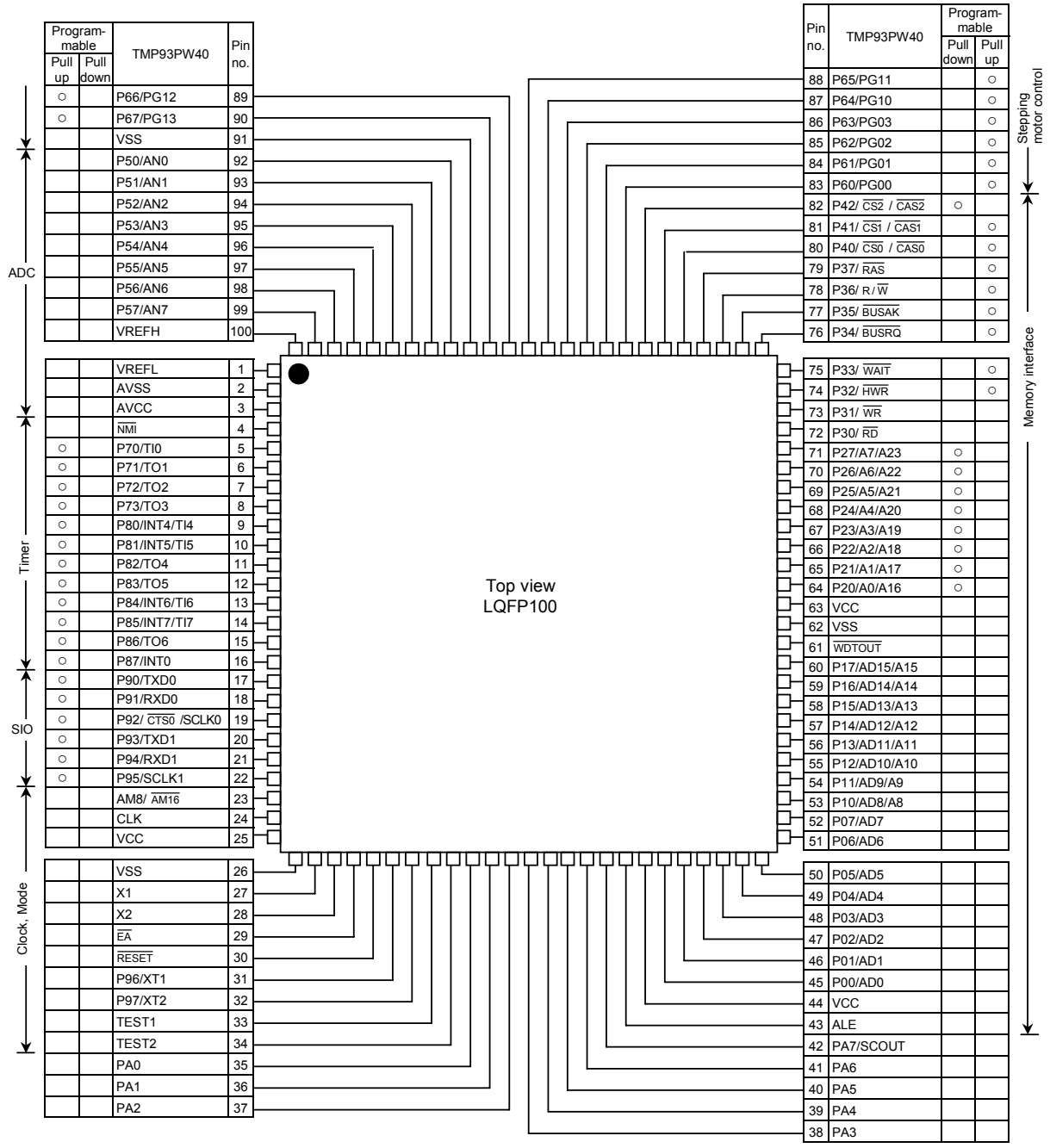
Figure 1.2 TMP93PW40 Block Diagram

2. Pin Assignment and Functions

The assignment of input/output pins for TMP93PW40, their name and outline functions are described below.

2.1 Pin Assignment

Figure 2.1.1 shows pin assignment of TMP93PW40.



Program-mable Pull up	Program-mable Pull down	TMP93PW40	Pin no.
○		P66/PG12	89
○		P67/PG13	90
		VSS	91
		P50/AN0	92
		P51/AN1	93
		P52/AN2	94
		P53/AN3	95
		P54/AN4	96
		P55/AN5	97
		P56/AN6	98
		P57/AN7	99
		VREFH	100
		VREFL	1
		AVSS	2
		AVCC	3
		$\overline{NMI}$	4
○		P70/TI0	5
○		P71/TO1	6
○		P72/TO2	7
○		P73/TO3	8
○		P80/INT4/TI4	9
○		P81/INT5/TI5	10
○		P82/TO4	11
○		P83/TO5	12
○		P84/INT6/TI6	13
○		P85/INT7/TI7	14
○		P86/TO6	15
○		P87/INT0	16
○		P90/TXD0	17
○		P91/RXD0	18
○		P92/ $\overline{CTS0}$ /SCLK0	19
○		P93/TXD1	20
○		P94/RXD1	21
○		P95/SCLK1	22
		AM8/ $\overline{AM16}$	23
		CLK	24
		VCC	25
		VSS	26
		X1	27
		X2	28
		$\overline{EA}$	29
		$\overline{RESET}$	30
		P96/XT1	31
		P97/XT2	32
		TEST1	33
		TEST2	34
		PA0	35
		PA1	36
		PA2	37

Pin no.	TMP93PW40	Program-mable Pull down	Program-mable Pull up
88	P65/PG11		○
87	P64/PG10		○
86	P63/PG03		○
85	P62/PG02		○
84	P61/PG01		○
83	P60/PG00		○
82	P42/ $\overline{CS2}$ / $\overline{CAS2}$	○	
81	P41/ $\overline{CS1}$ / $\overline{CAS1}$		○
80	P40/ $\overline{CS0}$ / $\overline{CAS0}$		○
79	P37/ $\overline{RAS}$		○
78	P36/ R/ $\overline{W}$		○
77	P35/ $\overline{BUSAK}$		○
76	P34/ $\overline{BUSRQ}$		○
75	P33/ $\overline{WAIT}$		○
74	P32/ $\overline{HWR}$		○
73	P31/ $\overline{WR}$		
72	P30/ $\overline{RD}$		
71	P27/A7/A23	○	
70	P26/A6/A22	○	
69	P25/A5/A21	○	
68	P24/A4/A20	○	
67	P23/A3/A19	○	
66	P22/A2/A18	○	
65	P21/A1/A17	○	
64	P20/A0/A16	○	
63	VCC		
62	VSS		
61	$\overline{WDTOUT}$		
60	P17/AD15/A15		
59	P16/AD14/A14		
58	P15/AD13/A13		
57	P14/AD12/A12		
56	P13/AD11/A11		
55	P12/AD10/A10		
54	P11/AD9/A9		
53	P10/AD8/A8		
52	P07/AD7		
51	P06/AD6		
50	P05/AD5		
49	P04/AD4		
48	P03/AD3		
47	P02/AD2		
46	P01/AD1		
45	P00/AD0		
44	VCC		
43	ALE		
42	PA7/SCOUT		
41	PA6		
40	PA5		
39	PA4		
38	PA3		

Figure 2.1.1 Pin Assignment (100-Pin LQFP)

2.2 Pin Names and Functions

The names of the input/output pins and their functions are described below.

(1) Pin names and functions of TMP93PW40 in MCU mode. (Table 2.2.1 to Table 2.2.4)

Table 2.2.1 Names and Functions in MCU Mode (1/4)

Pin Names	Number of Pins	I/O	Functions
P00 to P07	8	I/O	Port 0: I/O port that allows I/O to be selected on a bit basis.
AD0 to AD7		3 state	Address/data (lower) : 0 to 7 for address/data bus.
P10 to P17	8	I/O	Port 1: I/O port that allows I/O to be selected on a bit basis.
AD8 to AD15		3 state	Address/data (upper): 8 to 15 for address/data bus.
A8 to A15		Output	Address: 8 to 15 for address bus.
P20 to P27	8	I/O	Port 2: I/O port that allows selection of I/O on a bit basis (with pull-down resistor).
A0 to A7		Output	Address: 0 to 7 for address bus.
A16 to A23		Output	Address: 16 to 23 for address bus.
P30	1	Output	Port 30: Output port.
$\overline{RD}$		Output	Read: Strobe signal for reading external memory.
P31	1	Output	Port 31: Output port.
$\overline{WR}$		Output	Write: Strobe signal for writing data on pins AD0 to AD7.
P32	1	I/O	Port 32: I/O port (with pull-up resistor).
$\overline{HWR}$		Output	High write: Strobe signal for writing data on pins AD8 to AD15.
P33	1	I/O	Port 33: I/O port (with pull-up resistor).
$\overline{WAIT}$		Input	Wait: Pin used to request CPU bus wait.
P34	1	I/O	Port 34: I/O port (with pull-up resistor).
$\overline{BUSRQ}$		Input	Bus request: Signal used to request high impedance for AD0 to AD15, A0 to A23, $\overline{RD}$, $\overline{WR}$, $\overline{HWR}$, R/$\overline{W}$, $\overline{RAS}$, $\overline{CS0}$, $\overline{CS1}$, and $\overline{CS2}$ pins. (for external DMAC)
P35	1	I/O	Port 35: I/O port (with pull-up resistor).
$\overline{BUSAK}$		Output	Bus acknowledge: Signal indicating that AD0 to AD15, A0 to A23, $\overline{RD}$, $\overline{WR}$, $\overline{HWR}$, R/$\overline{W}$, $\overline{RAS}$, $\overline{CS0}$, $\overline{CS1}$, and $\overline{CS2}$ pins are at high impedance after receiving $\overline{BUSRQ}$. (for external DMAC)
P36	1	I/O	Port 36: I/O port (with pull-up resistor).
R/$\overline{W}$		Output	Read/write: 1 represents read or dummy cycle; 0, write cycle.
P37	1	I/O	Port 37: I/O port (with pull-up resistor).
$\overline{RAS}$		Output	Row address strobe: Outputs $\overline{RAS}$ strobe for DRAM.
P40	1	I/O	Port 40: I/O port (with pull-up resistor).
$\overline{CS0}$		Output	Chip select 0: Outputs 0 when address is within specified address area.
$\overline{CAS0}$		Output	Column address strobe 0: Outputs $\overline{CAS}$ strobe for DRAM when address is within specified address area.

Note: With the external DMA controller, this device's built-in memory or built-in I/O cannot be accessed using the $\overline{BUSRQ}$ and $\overline{BUSAK}$ pins.

Table 2.2.2 Names and Functions in MCU Mode (2/4)

Pin Names	Number of Pins	I/O	Functions
P41	1	I/O	Port 41: I/O port (with pull-up resistor).
$\overline{CS1}$		Output	Chip select 1: Outputs 0 if address is within specified address area.
$\overline{CAS1}$		Output	Column address strobe 1: Outputs $\overline{CAS}$ strobe for DRAM if address is within specified address area.
P42	1	I/O	Port 42: I/O port (with pull-down resistor).
$\overline{CS2}$		Output	Chip select 2: Outputs 0 if address is within specified address area.
$\overline{CAS2}$		Output	Column address strobe 2: Outputs $\overline{CAS}$ strobe for DRAM if address is within specified address area.
P50 to P57	8	Input	Port 5: Input port.
AN0 to AN7		Input	Analog input: Input to AD converter.
VREFH	1	Input	Pin for reference voltage input to AD converter (H).
VREFL	1	Input	Pin for reference voltage input to AD converter (L).
P60 to P63	4	I/O	Ports 60 to 63: I/O ports that allow selection of I/O on a bit basis (with pull-up resistor).
PG00 to PG03		Output	Pattern generator ports: 00 to 03.
P64 to P67	4	I/O	Ports 64 to 67: I/O ports that allow selection of I/O on a bit basis (with pull-up resistor).
PG10 to PG13		Output	Pattern generator ports: 10 to 13.
P70	1	I/O	Port 70: I/O port (with pull-up resistor).
TI0		Input	Timer input 0: Timer 0 input.
P71	1	I/O	Port 71: I/O port (with pull-up resistor).
TO1		Output	Timer output 1: Timer 0 or 1 output.
P72	1	I/O	Port 72: I/O port (with pull-up resistor).
TO2		Output	PWM output 2: 8-bit PWM timer 2 output.
P73	1	I/O	Port 73: I/O port (with pull-up resistor).
TO3		Output	PWM output 3: 8-bit PWM timer 3 output.
P80	1	I/O	Port 80: I/O port (with pull-up resistor).
TI4		Input	Timer input 4: Timer 4 count/capture trigger signal input.
INT4		Input	Interrupt request pin 4: Interrupt request pin with programmable rising/falling edge.
P81	1	I/O	Port 81: I/O port (with pull-up resistor).
TI5		Input	Timer input 5: Timer 4 count/capture trigger signal input.
INT5		Input	Interrupt request pin 5: Interrupt request pin with rising edge.
P82	1	I/O	Port 82: I/O port (with pull-up resistor).
TO4		Output	Timer output 4: Timer 4 output pin.
P83	1	I/O	Port 83: I/O port (with pull-up resistor).
TO5		Output	Timer output 5: Timer 4 output pin.

Table 2.2.3 Names and Functions in MCU Mode (3/4)

Pin names	Number of pins	I/O	Functions
P84 TI6 INT6	1	I/O Input Input	Port 84: I/O port (with pull-up resistor). Timer input 6: Timer 5 count/capture trigger signal input. Interrupt request pin 6: Interrupt request pin with programmable rising/falling edge.
P85 TI7 INT7	1	I/O Input Input	Port 85: I/O port (with pull-up resistor). Timer input 7: Timer 5 count/capture trigger signal input. Interrupt request pin 7: Interrupt request pin with rising edge.
P86 TO6	1	I/O Output	Port 86: I/O port (with pull-up resistor). Timer output 6: Timer 5 output pin.
P87 INT0	1	I/O Input	Port 87: I/O port (with pull-up resistor). Interrupt request pin 0: Interrupt request pin with programmable level/rising edge.
P90 TXD0	1	I/O Output	Port 90: I/O port (with pull-up resistor). Serial send data 0.
P91 RXD0	1	I/O Input	Port 91: I/O port (with pull-up resistor). Serial receive data 0.
P92 $\overline{CTS0}$ SCLK0	1	I/O Input I/O	Port 92: I/O port (with pull-up resistor). Serial data send enable 0 (Clear to send). Serial clock I/O 0.
P93 TXD1	1	I/O Output	Port 93: I/O port (with pull-up resistor). Serial send data 1.
P94 RXD1	1	I/O Input	Port 94: I/O port (with pull-up resistor). Serial receive data 1.
P95 SCLK1	1	I/O I/O	Port 95: I/O port (with pull-up resistor). Serial clock I/O 1.
PA0 to PA6	7	I/O	Port A: I/O ports.
PA7 SCOUT	1	I/O Output	Port A7: I/O port. System clock output: Outputs system clock or 1/2 oscillation clock for synchronizing to external circuit.
$\overline{WDTOUT}$	1	Output	Watchdog timer output pin.
$\overline{NMI}$	1	Input	Non-maskable interrupt request pin: Interrupt request pin with falling edge. Can also be operated at rising edge by program.
CLK	1	Output	Clock output: Outputs “system clock ÷ 2” clock. Pulled-up during reset. Can be set to output disable for reducing noise.
$\overline{EA}$	1	Input	External access: “1” should be inputted with TMP93PW40.

Table 2.2.4 Names and Functions in MCU Mode (4/4)

Pin Names	Number of Pins	I/O	Functions
AM8/ $\overline{\text{AM16}}$	1	Input	Address mode: Selects external data bus width. "1" should be inputted. The data bus width for external access is set by chip select/wait control register, port 1 control register.
ALE	1	Output	Address latch enable Can be set to output disable for reducing noise.
$\overline{\text{RESET}}$	1	Input	Reset: Initializes LSI. (with pull-up resistor)
X1/X2	2	Input/Output	High-frequency oscillator connecting pin.
XT1 P96	1	Input I/O	Low-frequency oscillator connecting pin. Port 96: I/O port (open-drain output).
XT2 P97	1	Output I/O	Low-frequency oscillator connecting pin. Port 97: I/O port (open-drain output).
TEST1/TEST2	2	Output/Input	TEST1 should be connected with TEST2 pin. Do not connect to any other pins.
VCC	3		Power supply pin.
VSS	3		GND pin (0 V).
AVCC	1		Power supply pin for AD converter.
AVSS	1		GND pin for AD converter (0 V).

Note: Pull-up/pull-down resistor can be released from the pin by software (except $\overline{\text{RESET}}$ pin).

(2) PROM mode

Table 2.2.5 Names and Functions of PROM Mode

Pin Function	Pin Number	Input/ Output	Function	Pin Name (MCU Mode)
A7 to A0	8	Input	Memory address of program	P27 to P20
A15 to A8	8	Input		P17 to P10
A16	1	Input		P33
D7 to D0	8	I/O	Memory data of program	P07 to P00
$\overline{CE}$	1	Input	Chip enable	P32
$\overline{OE}$	1	Input	Output control	P30
$\overline{PGM}$	1	Input	Program control	P31
VPP	1	Power supply	12.75 V/5 V (Power supply of program)	$\overline{EA}$
VCC	4	Power supply	6.25 V/5 V	VCC, AVCC
VSS	4	Power supply	0 V	VSS, AVSS

Pin Function	Pin Number	Input/ Output	Disposal of Pin
P34	1	Input	Fix to low level (security pin)
$\overline{RESET}$	1	Input	Fix to low level (PROM mode)
CLK	1	Input	
ALE	1	Output	Open
X1	1	Input	Crystal
X2	1	Output	
P42 to P40 P37 to P35 AM8/ $\overline{AM16}$	7	Input	Fix to high level
TEST1, TEST2	2	Input/ Output	TEST1 should be connected with TEST2 pin. Do not connect to any other pins.
P57 to P50 P67 to P60 P73 to P70 P87 to P80 P97 to P90 PA7 to PA0 VREFH VREFL $\overline{NMI}$ $\overline{WDTOUT}$	48	I/O	Open

3. Operation

This section describes in blocks the functions and basic operations of TMP93PW40.

The TMP93PW40 has ROM in place of the mask ROM which is included in the TMP93CW40. The other configuration and functions are the same as the TMP93CW40. Regarding the function of the TMP93PW40, which is not described herein, see the TMP93CW40.

The TMP93PW40 has two operational modes: MCU mode and PROM mode.

3.1 MCU Mode

(1) Mode setting and function

The MCU mode is set by opening the CLK pin (Output status). In the MCU mode, the operation is same as TMP93CW40.

3.2 Memory Map

Figure 3.2.1 are memory map of the TMP93PW40.

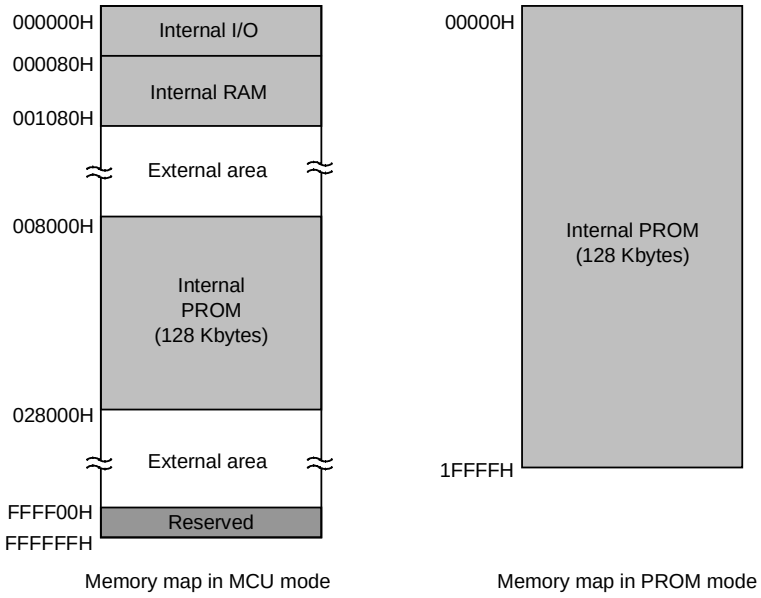


Figure 3.2.1 Memory Map

3.3 PROM Mode

(1) Mode setting and function

PROM mode is set by setting the $\overline{\text{RESET}}$ and CLK pins to the "L" level. The programming and verification for the internal PROM is achieved by using a general PROM programmer with the adaptor socket.

a. OTP adaptor

BM11129: TMP93PS40DF, TMP93PW40DF adaptors

b. Setting OTP adaptor

Set the switch (SW1) to N side.

c. Setting PROM programmer

i) Set PROM type to TC571000D.

Size: 1 Mbits (128 K × 8 bits)

VPP: 12.75 V

tpw: 100 μs

The electric signature mode (Hereinafter referred to as "signature".) is not supported. Therefore if signature is used, the device is damaged because 12.75 V is applied to A9 of address. Do not use signature.

ii) Transferring the data (copy)

In TMP93PW40, PROM is placed on addresses 00000 to 1FFFFH in PROM mode, and addresses 08000H to 27FFFH in MCU mode. Therefore data should be transferred to addresses 00000 to 1FFFFH in PROM mode using the object converter (tuconv) or the block transfer mode (see instruction manual of PROM programmer.) or making the object data.

iii) Setting the programming address

Start address: 00000H

End address: 1FFFFH

d. Programming

Program/verify according to the procedures of PROM programmer.

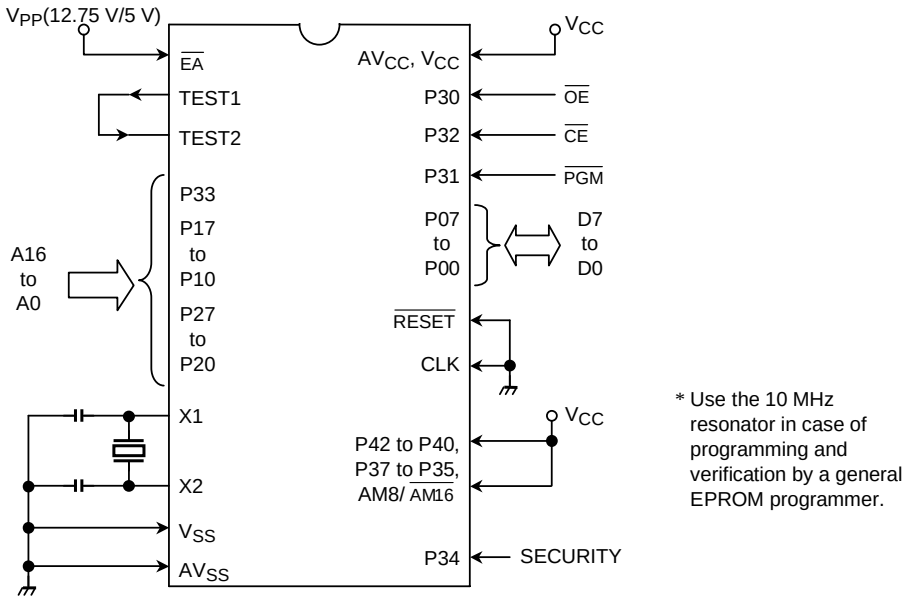


Figure 3.3.1 PROM Mode Pin Setting

(2) Programming flow chart

The programming mode is set by applying 12.75 V (programming voltage) to the VPP pin when the following pins are set as follows,

(VCC: 6.25 V, $\overline{\text{RESET}}$: "L" level, CLK: "L" level).

While address and data are fixed and $\overline{\text{CE}}$ pin is set to "L" level, 0.1 ms of "L" level pulse is applied to $\overline{\text{PGM}}$ pin to program the data.

Then the data in the address is verified.

If the programmed data is incorrect, another 0.1 ms pulse is applied to $\overline{\text{PGM}}$ pin.

This programming procedure is repeated until correct data is read from the address. (25 times maximum)

Subsequently, all data are programmed in all addresses.

The verification for all data is done under the condition of $V_{PP} = V_{CC} = 5$ V after all data were written.

Figure 3.3.2 shows the programming flow chart.

High Speed Program Writing

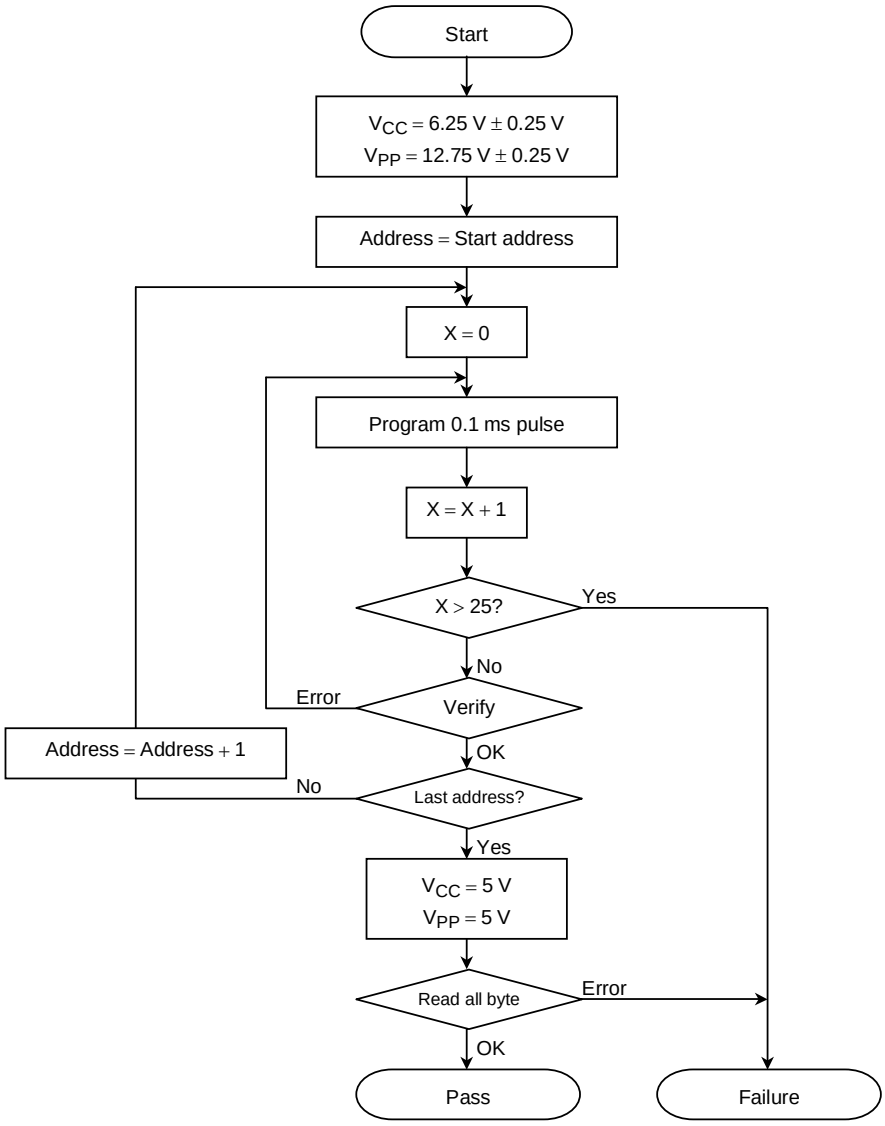


Figure 3.3.2 Flow Chart

(3) Security bit

The TMP93PW40 has a security bit.

If the security bit is programmed to "0", the content of the PROM can not be read in PROM mode.
(Outputs data FFH)

How to program the security bit.

The difference from the programming procedures described in section 3.3 (1) are follows.

a. Setting OTP adapter

Set the switch (SW1) to S side.

b. Setting PROM programmer

ii) Transferring the data

iii) Setting programming address

The security bit is in bit 0 of address 00000H.

Set the start address 00000H and the end address 00000H.

Set the data FEH at the address 00000H.

4. Electrical Characteristics

"X" used in an expression shows a frequency of clock f_{FPH} selected by SYSCR1<SYSCK>. If a clock gear or a low speed oscillator is selected, a value of "X" is different. The value in an example is calculated at fc, gear = 1/fc (SYSCR1 < SYSCK, GEAR2:0 > = "0000").

4.1 Maximum Ratings (TMP93PW40DF)

Parameter	Symbol	Rating	Unit
Power supply voltage	V_{CC}	−0.5 to 6.5	V
Input voltage	V_{IN}	−0.5 to V_{CC} + 0.5	V
Output current (total)	ΣI_{OL}	120	mA
Output current (total)	ΣI_{OH}	−80	mA
Power dissipation (Ta = 85°C)	P_D	600	mW
Soldering temperature (10 s)	T_{SOLDER}	260	°C
Storage temperature	T_{STG}	−65 to 150	°C
Operating temperature	T_{OPR}	−40 to 85	°C

Note: The 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 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 maximum rating value will ever be exceeded.

4.2 DC Characteristics (1/2)

Ta = −40 to 85°C

Parameter		Symbol	Condition		Min	Typ. (Note)	Max	Unit
Power supply voltage ($AV_{CC} = V_{CC}$ / $AV_{CC} = V_{SS} = 0$ V)		V_{CC}	fc = 4 to 20 MHz	fs = 30 to 34 kHz	4.5		5.5	V
			fc = 4 to 12.5 MHz		2.7			
Input low voltage	AD0 to AD15	V_{IL}	$V_{CC} \geq 4.5$ V		−0.3		0.8	V
			$V_{CC} < 4.5$ V				0.6	
	Port 2 to port A (except P87)	V_{IL1}	V_{CC} = 2.7 to 5.5 V				0.3 V_{CC}	
	$\overline{RESET}$, $\overline{NMI}$, INT0	V_{IL2}					0.25 V_{CC}	
	$\overline{EA}$, AM8/ $\overline{AM16}$	V_{IL3}					0.3	
	X1	V_{IL4}					0.2 V_{CC}	
Input high voltage	AD0 to AD15	V_{IH}	$V_{CC} \geq 4.5$ V		2.2		V_{CC} + 0.3	
			$V_{CC} < 4.5$ V		2.0			
	Port 2 to port A (except P87)	V_{IH1}	V_{CC} = 2.7 to 5.5 V		0.7 V_{CC}			
	$\overline{RESET}$, $\overline{NMI}$, INT0	V_{IH2}			0.75 V_{CC}			
	$\overline{EA}$, AM8/ $\overline{AM16}$	V_{IH3}			V_{CC} − 0.3			
	X1	V_{IH4}			0.8 V_{CC}			
Output low voltage		V_{OL}	I_{OL} = 1.6 mA (V_{CC} = 2.7 to 5.5 V)				0.45	V
Output high voltage		V_{OH1}	I_{OH} = −400 μA (V_{CC} = 3 V ± 10%)		2.4			
		V_{OH2}	I_{OH} = −400 μA (V_{CC} = 5 V ± 10%)		4.2			

Note: Typical values are for Ta = 25°C and V_{CC} = 5 V unless otherwise noted.

4.2 DC Characteristics (2/2)

Parameter	Symbol	Condition	Min	Typ. (Note 1)	Max	Unit
Darlington drive current (8 output pins max)	I_{DAR} (Note 2)	V_{EXT} = 1.5 V, R_{EXT} = 1.1 kΩ (when V_{CC} = 5 V ± 10%)	−1.0		−3.5	mA
Input leakage current	I_{LI}	0.0 ≤ V_{IN} ≤ V_{CC}		0.02	±5	μA
Output leakage current	I_{LO}	0.2 ≤ V_{IN} ≤ V_{CC} − 0.2		0.05	±10	
Powerdown voltage (at STOP, RAM back-up)	V_{STOP}	V_{IL2} = 0.2 V_{CC}, V_{IH2} = 0.8 V_{CC}	2.0		6.0	V
$\overline{RESET}$ pull-up resistor	R_{RST}	V_{CC} = 5 V ± 10%	50		150	kΩ
		V_{CC} = 3 V ± 10%	80		200	
Pin capacitance	C_{IO}	fc = 1 MHz			10	pF
Schmitt width $\overline{RESET}$, $\overline{NMI}$, INT0	V_{TH}		0.4	1.0		V
Programmable pull-down resistor	R_{KL}	V_{CC} = 5 V ± 10%	10		80	kΩ
		V_{CC} = 3 V ± 10%	30		150	
Programmable pull-up resistor	R_{KH}	V_{CC} = 5 V ± 10%	50		150	
		V_{CC} = 3 V ± 10%	100		300	
NORMAL (Note 3)	I_{CC}	V_{CC} = 5 V ± 10%, fc = 20 MHz		19	25	mA
NORMAL2 (Note 4)				24	30	
RUN				17	25	
IDLE2				10	15	
IDLE1				3.5	5	
NORMAL (Note 3)		V_{CC} = 3 V ± 10%, fc = 12.5 MHz (Typ. : V_{CC} = 3.0 V)		6.5	10	mA
NORMAL2 (Note 4)				9.5	13	
RUN				5.0	9	
IDLE2				3.0	5	
IDLE1				0.8	1.5	
SLOW (Note 3)		V_{CC} = 3 V ± 10%, fs = 32.768 kHz (Typ. :V_{CC} = 3.0 V)		20	45	μA
RUN				16	40	
IDLE2				10	30	
IDLE1				5	25	
STOP		Ta ≤ 50°C		0.2	10	μA
		Ta ≤ 70°C			20	
		Ta ≤ 85°C			50	

Note 1: Typical values are for Ta = 25°C and V_{CC} = 5 V unless otherwise noted.

Note 2: I_{DAR} is guranteed for total of up to 8 ports.

Note 3: The condition of measurement of I_{CC} (NORMAL/SLOW).
Only CPU operates. Output ports are open and Input ports fixed.

Note 4: The condition of measurement of I_{CC} (NORMAL 2).
CPU and all peripherals operate. Output ports are open and input ports fixed.

4.3 AC Characteristics

(1) $V_{CC} = 5\ V \pm 10\%$

No.	Parameter	Symbol	Variable		16 MHz		20 MHz		Unit
			Min	Max	Min	Max	Min	Max	
1	Osc. period (= x)	t_{OSC}	50	31250	62.5		50		ns
2	CLK pulse width	t_{CLK}	2x – 40		85		60		ns
3	A0 to A23 valid → CLK hold	t_{AK}	0.5x – 20		11		5		ns
4	CLK valid → A0 to A23 hold	t_{KA}	1.5x – 70		24		5		ns
5	A0 to A15 valid → ALE fall	t_{AL}	0.5x – 15		16		10		ns
6	ALE fall → A0 to A15 hold	t_{LA}	0.5x – 20		11		5		ns
7	ALE high pulse width	t_{LL}	x – 40		23		10		ns
8	ALE fall → $\overline{RD}$ / $\overline{WR}$ fall	t_{LC}	0.5x – 25		6		0		ns
9	$\overline{RD}$ / $\overline{WR}$ rise → ALE rise	t_{CL}	0.5x – 20		11		5		ns
10	A0 to A15 valid → $\overline{RD}$ / $\overline{WR}$ fall	t_{ACL}	x – 25		38		25		ns
11	A0 to A23 valid → $\overline{RD}$ / $\overline{WR}$ fall	t_{ACH}	1.5x – 50		44		25		ns
12	$\overline{RD}$ / $\overline{WR}$ rise → A0 to A23 hold	t_{CA}	0.5x – 25		6		0		ns
13	A0 to A15 valid → D0 to D15 input	t_{ADL}		3.0x – 55		133		95	ns
14	A0 to A23 valid → D0 to D15 input	t_{ADH}		3.5x – 65		154		110	ns
15	$\overline{RD}$ fall → D0 to D15 input	t_{RD}		2.0x – 60		65		40	ns
16	$\overline{RD}$ low pulse width	t_{RR}	2.0x – 40		85		60		ns
17	$\overline{RD}$ rise → D0 to D15 hold	t_{HR}	0		0		0		ns
18	$\overline{RD}$ rise → A0 to A15 output	t_{RAE}	x – 15		48		35		ns
19	$\overline{WR}$ low pulse width	t_{WW}	2.0x – 40		85		60		ns
20	D0 to D15 valid → $\overline{WR}$ rise	t_{DW}	2.0x – 55		70		45		ns
21	$\overline{WR}$ rise → D0 to D15 hold	t_{WD}	0.5x – 15		16		10		ns
22	A0 to A23 valid → $\overline{WAIT}$ input $\left[\frac{(1+N)\ WAIT}{mode}\right]$	t_{AWH}		3.5x – 90		129		85	ns
23	A0 to A15 valid → $\overline{WAIT}$ input $\left[\frac{(1+N)\ WAIT}{mode}\right]$	t_{AWL}		3.0x – 80		108		70	ns
24	$\overline{RD}$ / $\overline{WR}$ fall → $\overline{WAIT}$ hold $\left[\frac{(1+N)\ WAIT}{mode}\right]$	t_{CW}	2.0x + 0		125		100		ns
25	A0 to A23 valid → Port input	t_{APH}		2.5x – 120		36		5	ns
26	A0 to A23 valid → Port hold	t_{APH2}	2.5x + 50		206		175		ns
27	$\overline{WR}$ rise → Port valid	t_{CP}		200		200		200	ns
28	A0 to A23 valid → $\overline{RAS}$ fall	t_{ASRH}	1.0x – 40		23		10		ns
29	A0 to A15 valid → $\overline{RAS}$ fall	t_{ASRL}	0.5x – 15		16		10		ns
30	$\overline{RAS}$ fall → D0 to D15 input	t_{RAC}		2.5x – 70		86		55	ns
31	$\overline{RAS}$ fall → A0 to A15 hold	t_{RAH}	0.5x – 15		16		10		ns
32	$\overline{RAS}$ low pulse width	t_{RAS}	2.0x – 40		85		60		ns
33	$\overline{RAS}$ high pulse width	t_{RP}	2.0x – 40		85		60		ns
34	$\overline{CAS}$ fall → $\overline{RAS}$ rise	t_{RSH}	1.0x – 40		23		10		ns
35	$\overline{RAS}$ rise → $\overline{CAS}$ rise	t_{RSC}	0.5x – 25		6		0		ns
36	$\overline{RAS}$ fall → $\overline{CAS}$ fall	t_{RCD}	1.0x – 40		23		10		ns
37	$\overline{CAS}$ fall → D0 to D15 input	t_{CAC}		1.5x – 65		29		10	ns
38	$\overline{CAS}$ low pulse width	t_{CAS}	1.5x – 30		64		40		ns

AC measuring conditions

- Output level: High 2.2 V/Low 0.8 V, $C_L = 50$ pF
  (However $C_L = 100$ pF for AD0 to AD15, A0 to A23, ALE, $\overline{RD}$, $\overline{WR}$, $\overline{HWR}$, R/$\overline{W}$, CLK, $\overline{RAS}$, $\overline{CAS0}$ to $\overline{CAS2}$)
- Input level: High 2.4 V/Low 0.45 V (AD0 to AD15)
  High 0.8 V_{CC}/Low 0.2 V_{CC} (Except for AD0 to AD15)

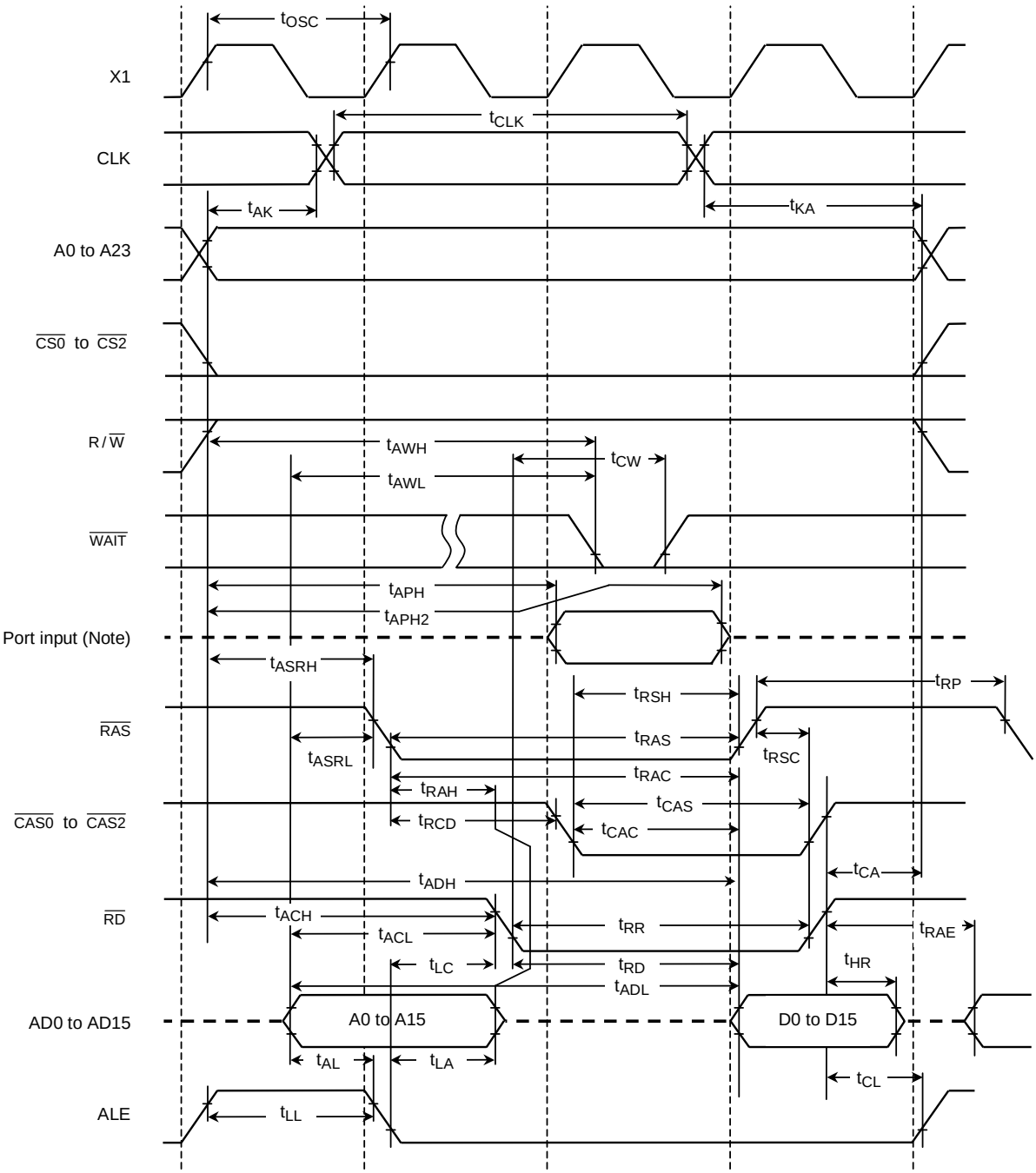
(2) $V_{CC} = 3\ V \pm 10\%$

No.	Parameter	Symbol	Variable		12.5 MHz		Unit
			Min	Max	Min	Max	
1	Osc. period (= x)	t_{OSC}	80	31250	80		ns
2	CLK pulse width	t_{CLK}	2x – 40		120		ns
3	A0 to A23 valid → CLK hold	t_{AK}	0.5x – 30		10		ns
4	CLK valid → A0 to A23 hold	t_{KA}	1.5x – 80		40		ns
5	A0 to A15 valid → ALE fall	t_{AL}	0.5x – 35		5		ns
6	ALE fall → A0 to A15 hold	t_{LA}	0.5x – 35		5		ns
7	ALE high pulse width	t_{LL}	x – 60		20		ns
8	ALE fall → $\overline{RD}$ / $\overline{WR}$ fall	t_{LC}	0.5x – 35		5		ns
9	$\overline{RD}$ / $\overline{WR}$ rise → ALE rise	t_{CL}	0.5x – 40		0		ns
10	A0 to A15 valid → $\overline{RD}$ / $\overline{WR}$ fall	t_{ACL}	x – 50		30		ns
11	A0 to A23 valid → $\overline{RD}$ / $\overline{WR}$ fall	t_{ACH}	1.5x – 50		70		ns
12	$\overline{RD}$ / $\overline{WR}$ rise → A0 to A23 hold	t_{CA}	0.5x – 40		0		ns
13	A0 to A15 valid → D0 to D15 input	t_{ADL}		3.0x – 110		130	ns
14	A0 to A23 valid → D0 to D15 input	t_{ADH}		3.5x – 125		155	ns
15	$\overline{RD}$ fall → D0 to D15 input	t_{RD}		2.0x – 115		45	ns
16	$\overline{RD}$ low pulse width	t_{RR}	2.0x – 40		120		ns
17	$\overline{RD}$ rise → D0 to D15 hold	t_{HR}	0		0		ns
18	$\overline{RD}$ rise → A0 to A15 output	t_{RAE}	x – 25		55		ns
19	$\overline{WR}$ low pulse width	t_{WW}	2.0x – 40		120		ns
20	D0 to D15 valid → $\overline{WR}$ rise	t_{DW}	2.0x – 120		40		ns
21	$\overline{WR}$ rise → D0 to D15 hold	t_{WD}	0.5x – 40		0		ns
22	A0 to A23 valid → $\overline{WAIT}$ input [(1 + N) WAIT mode]	t_{AWH}		3.5x – 130		150	ns
23	A0 to A15 valid → $\overline{WAIT}$ input [(1 + N) WAIT mode]	t_{AWL}		3.0x – 100		140	ns
24	$\overline{RD}$ / $\overline{WR}$ fall → $\overline{WAIT}$ hold [(1 + N) WAIT mode]	t_{CW}	2.0x + 0		160		ns
25	A0 to A23 valid → Port input	t_{APH}		2.5x – 195		5	ns
26	A0 to A23 valid → Port hold	t_{APH2}	2.5x + 50		250		ns
27	$\overline{WR}$ rise → Port valid	t_{CP}		200		200	ns
28	A0 to A23 valid → $\overline{RAS}$ fall	t_{ASRH}	1.0x – 60		20		ns
29	A0 to A15 valid → $\overline{RAS}$ fall	t_{ASRL}	0.5x – 40		0		ns
30	$\overline{RAS}$ fall → D0 to D15 input	t_{RAC}		2.5x – 90		110	ns
31	$\overline{RAS}$ fall → A0 to A15 hold	t_{RAH}	0.5x – 25		15		ns
32	$\overline{RAS}$ low pulse width	t_{RAS}	2.0x – 40		120		ns
33	$\overline{RAS}$ high pulse width	t_{RP}	2.0x – 40		120		ns
34	$\overline{CAS}$ fall → $\overline{RAS}$ rise	t_{RSH}	1.0x – 55		25		ns
35	$\overline{RAS}$ rise → $\overline{CAS}$ rise	t_{RSC}	0.5x – 25		15		ns
36	$\overline{RAS}$ fall → $\overline{CAS}$ fall	t_{RCD}	1.0x – 40		40		ns
37	$\overline{CAS}$ fall → D0 to D15 input	t_{CAC}		1.5x – 120		0	ns
38	$\overline{CAS}$ low pulse width	t_{CAS}	1.5x – 40		80		ns

AC measuring conditions

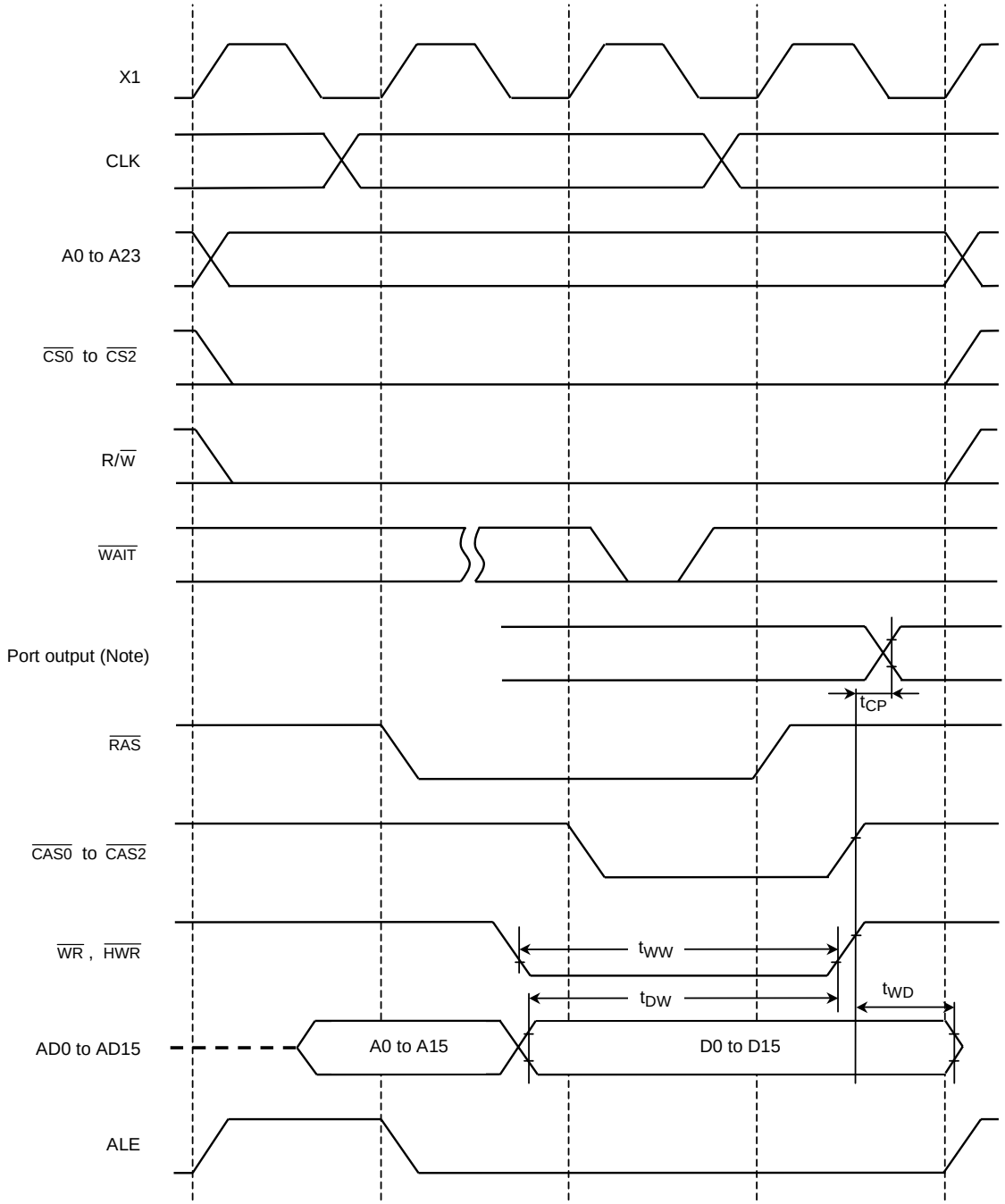
- Output level: High $0.7 \times V_{CC}$/Low $0.3 \times V_{CC}$, $C_L = 50$ pF
- Input level: High $0.9 \times V_{CC}$/Low $0.1 \times V_{CC}$

(1) Read cycle



Note: Since the CPU accesses the internal area to read data from a port, the control signals of external pins such as $\overline{RD}$ and $\overline{CS}$ are not enabled. Therefore, the above waveform diagram should be regarded as depicting internal operation. Please also note that the timing and AC characteristics of port input/output shown above are typical representation. For details, contact your local Toshiba sales representative.

(2) Write cycle



Note: Since the CPU accesses the internal area to write data to a port, the control signals of external pins such as $\overline{WR}$ and $\overline{CS}$ are not enabled. Therefore, the above waveform diagram should be regarded as depicting internal operation. Please also note that the timing and AC characteristics of port input/output shown above are typical representation. For details, contact your local Toshiba sales representative.

4.4 AD Conversion Characteristics

$AV_{CC} = V_{CC}$, $AV_{SS} = V_{SS}$

Parameter	Symbol	Power Supply	Min	Typ.	Max	Unit
Analog reference voltage (+)	V_{REFH}	$V_{CC} = 5 V \pm 10\%$	$V_{CC} - 1.5 V$	V_{CC}	V_{CC}	V
		$V_{CC} = 3 V \pm 10\%$	$V_{CC} - 0.2 V$	V_{CC}	V_{CC}	
Analog reference voltage (–)	V_{REFL}	$V_{CC} = 5 V \pm 10\%$	V_{SS}	V_{SS}	$V_{SS} + 0.2 V$	
		$V_{CC} = 3 V \pm 10\%$	V_{SS}	V_{SS}	$V_{SS} + 0.2 V$	
Analog input voltage range	V_{AIN}		V_{REFL}		V_{REFH}	
Analog current for analog reference voltage <VREFON> = 1	I_{REF} ($V_{REFL} = 0 V$)	$V_{CC} = 5 V \pm 10\%$		0.5	1.5	mA
		$V_{CC} = 3 V \pm 10\%$		0.3	0.9	
<VREFON> = 0		$V_{CC} = 2.7$ to $5.5 V$		0.02	5.0	μA
Error (excluding quantizing error)	–	$V_{CC} = 5 V \pm 10\%$		±1.0	±3.0	LSB
		$V_{CC} = 3 V \pm 10\%$		±1.0	±3.0	

Note 1: $1LSB = (V_{REFH} - V_{REFL}) / 2^{10}$ [V]

Note 2: Minimum operation frequency

The operation of the AD converter is guaranteed only when fc (high-frequency oscillator) is used. (It is not guaranteed when fs is used.) Additionally, it is guaranteed with 4 MHz or more.

Note 3: The value I_{CC} includes the current which flows through the AV_{CC} pin.

4.5 Serial Channel Timing

(1) I/O interface mode

a. SCLK input mode

Parameter	Symbol	Variable		32.768 kHz (Note 1)		12.5 MHz		20 MHz		Unit
		Min	Max	Min	Max	Min	Max	Min	Max	
SCLK cycle	t_{SCY}	16X		488 μs		1280		800		ns
Output data → Rising edge or falling edge (Note 2) of SCLK	t_{OSS}	$t_{SCY}/2 - 5X - 50$		91.5 μs		190		100		ns
SCLK rising edge or falling edge (Note 2) → Output data hold	t_{OHS}	5X – 100		152 μs		300		150		ns
SCLK rising edge or falling edge (Note 2) → Input data hold	t_{HSR}	0		0		0		0		ns
SCLK rising edge or falling edge (Note 2) → Effective data input	t_{SRD}		$t_{SCY} - 5X - 100$		336 μs		780		450	ns

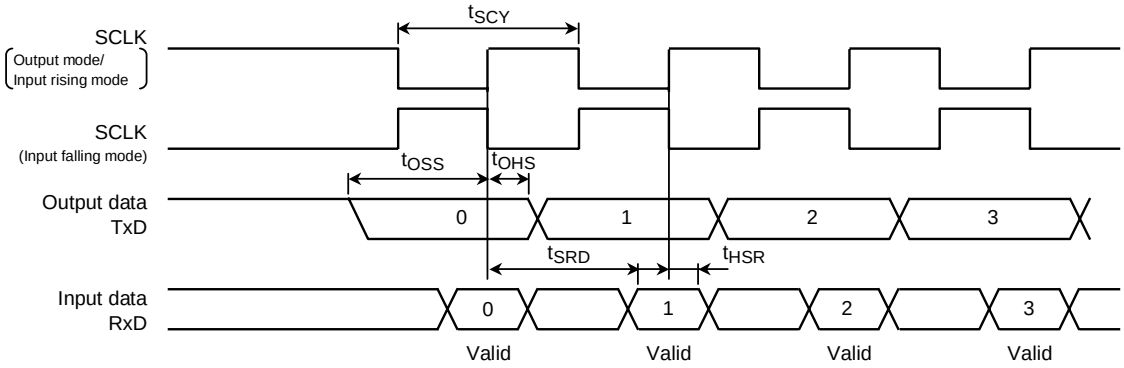
Note 1: When fs is used as system clock (f_{SYS}) or fs is used as input clock to prescaler.

Note 2: SCLK rising/falling timing … SCLK rising in the rising mode of SCLK, SCLK falling in the falling mode of SCLK.

b. SCLK output mode

Parameter	Symbol	Variable		32.768 kHz (Note)		12.5 MHz		20 MHz		Unit
		Min	Max	Min	Max	Min	Max	Min	Max	
SCLK cycle (programmable)	t_{SCY}	16X	8192X	488	250 ms	1.28	655.36	0.8	409.6	μs
Output data → SCLK rising edge	t_{OSS}	$t_{SCY} - 2X - 150$		427 μs		970		550		ns
SCLK rising edge → Output data hold	t_{OHS}	2X – 80		60 μs		80		20		ns
SCLK rising edge → Input data hold	t_{HSR}	0		0		0		0		ns
SCLK rising edge → Effective data input	t_{SRD}		$t_{SCY} - 2X - 150$		428 μs		970		550	ns

Note: When fs is used as system clock (f_{SYS}) or fs is used as input clock to prescaler.



4.6 Timer/Counter Input Clock (TI0, TI4, TI5, TI6 and TI7)

Parameter	Symbol	Variable		12.5 MHz		20 MHz		Unit
		Min	Max	Min	Max	Min	Max	
Clock cycle	t_{VCK}	8X + 100		740		500		ns
Low level clock pulse width	t_{VCKL}	4X + 40		360		240		ns
High level clock pulse width	t_{VCKH}	4X + 40		360		240		ns

4.7 Interrupt and Capture

(1) $\overline{NMI}$ and INT0 interrupts

Parameter	Symbol	Variable		12.5 MHz		20 MHz		Unit
		Min	Max	Min	Max	Min	Max	
$\overline{NMI}$, INT0 low level pulse width	t_{INTAL}	4X		320		200		ns
$\overline{NMI}$, INT0 high level pulse width	t_{INTAH}	4X		320		200		ns

(2) INT4 to 7 interrupts and capture

Input pulse width of INT4 to 7 depends on the operation clock of CPU and Timer (9 bit prescaler). The following shows the pulse width in each clock.

System Clock Selected <SYSCK>	Prescaler Clock Selected <PRCK1:0>	t_{INTBL} (INT4 to 7 low-level pulse width)		t_{INTBH} (INT4 to 7 high-level pulse width)		Unit
		Variable	20 MHz	Variable	20 MHz	
		Min	Min	Min	Min	
0 (fc)	00 (f_{FPH})	8X + 100	500	8X + 100	500	ns
	01 (fs)	8XT + 0.1	244.3	8XT + 0.1	244.3	μs
	10 (fc/16)	128X + 0.1	6.5	128X + 0.1	6.5	
1 (fs) (Note 2)	00 (f_{FPH})	8XT + 0.1	244.3	8XT + 0.1	244.3	
	01 (fs)					

Note 1: XT represents the cycle of the low frequency clock fs. Calculated at fs = 32.768 kHz.

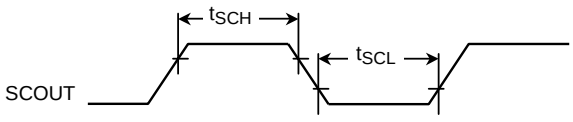
Note 2: When fs is used as the system clock, fc/16 can not be selected for the prescaler clock.

4.8 SCOUT Pin AC Characteristics

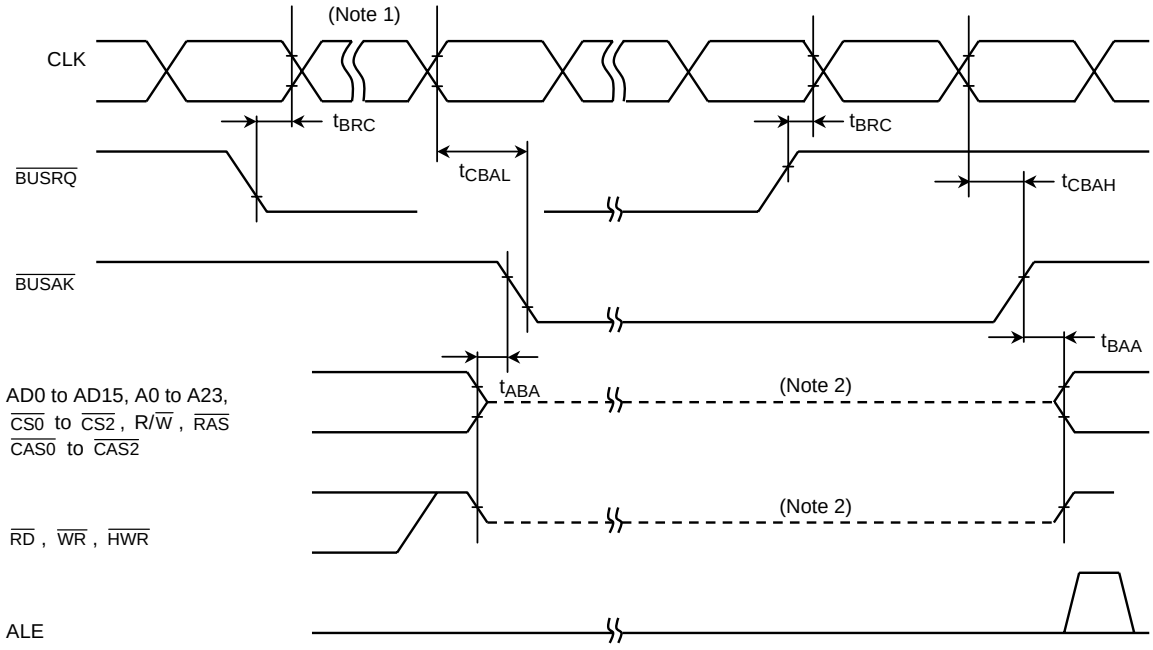
Parameter		Symbol	Variable		12.5 MHz		20 MHz		Unit
			Min	Max	Min	Max	Min	Max	
High-level pulse width	V_{CC} = 5 V ± 10%	t_{SCH}	0.5X – 10		30		15		ns
	V_{CC} = 3 V ± 10%		0.5X – 20		20		–	–	
Low-level pulse width	V_{CC} = 5 V ± 10%	t_{SCL}	0.5X – 10		30		15		ns
	V_{CC} = 3 V ± 10%		0.5X – 20		20		–	–	

Measurement condition

- Output level: High 2.2 V/Low 0.8 V, C_L = 10 pF



4.9 Timing Chart for Bus Request ($\overline{BUSRQ}$)/Bus Acknowledge ($\overline{BUSAK}$)



Parameter	Symbol	Variable		12.5 MHz		20 MHz		Unit
		Min	Max	Min	Max	Min	Max	
$\overline{BUSRQ}$ set-up time to CLK	t_{BRC}	120		120		120		ns
CLK → $\overline{BUSAK}$ falling edge	t_{CBAL}		1.5x + 120		240		195	ns
CLK → $\overline{BUSAK}$ rising edge	t_{CBAH}		0.5x + 40		80		65	ns
Output Buffer off to $\overline{BUSAK}$	t_{ABA}	0	80	0	80	0	80	ns
$\overline{BUSAK}$ to Output Buffer on	t_{BAA}	0	80	0	80	0	80	ns

Note 1: The Bus will be released after the $\overline{WAIT}$ request is inactive, when the $\overline{BUSRQ}$ is set to "0" during "Wait" cycle.

Note 2: This line only shows the output buffer is off-state.
It doesn't indicate the signal level is fixed.
Just after the bus is released, the signal level which is set before the bus is released is kept dynamically by the external capacitance. Therefore, to fix the signal level by an external resistor during bus releasing, designing is executed carefully because the level-fix will be delayed.
The internal programmable pull-up/pull-down resistor is switched active/non-active by an internal signal.

4.10 Read Operation in PROM Mode

DC/AC characteristics

Ta = 25 ± 5°C, V_{CC} = 5V ± 10%

Parameter	Symbol	Condition	Min	Max	Unit
V_{PP} read voltage	V_{PP}	–	4.5	5.5	V
Input high voltage (A0 to A16, $\overline{CE}$, $\overline{OE}$, $\overline{PGM}$)	V_{IH1}	–	2.2	V_{CC} + 0.3	V
Input low voltage (A0 to A16, $\overline{CE}$, $\overline{OE}$, $\overline{PGM}$)	V_{IL1}	–	–0.3	0.8	V
Address to output delay	V_{ACC}	C_L = 50 pF	–	$2.25T_{CYC} + \alpha$	ns

T_{CYC} = 400 ns (10 MHz clock)
α = 200 ns

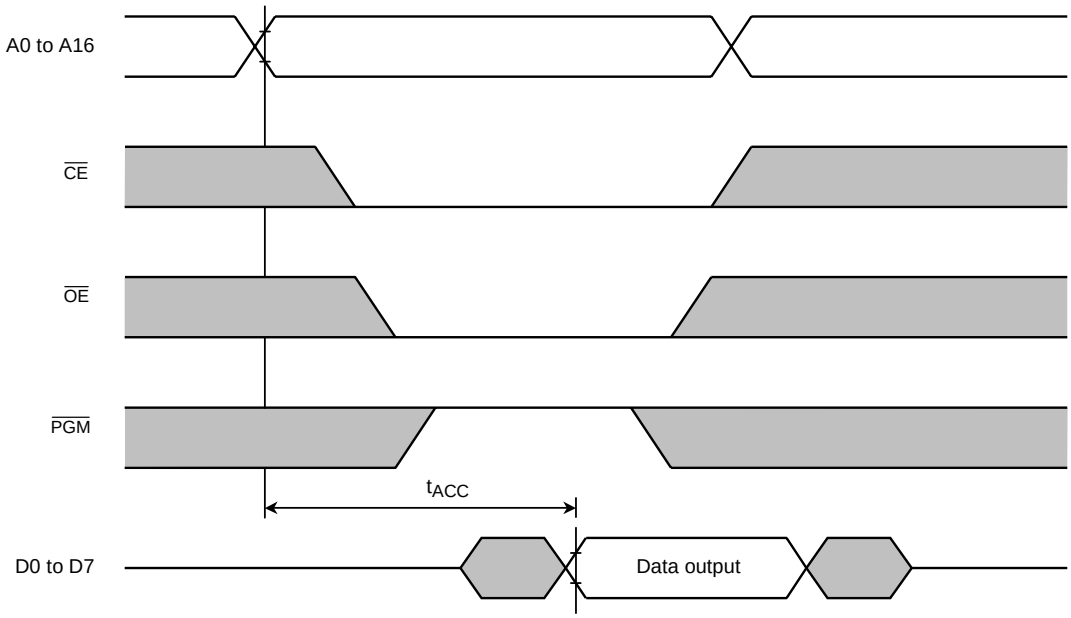
4.11 Program Operation in PROM Mode

DC/AC characteristics

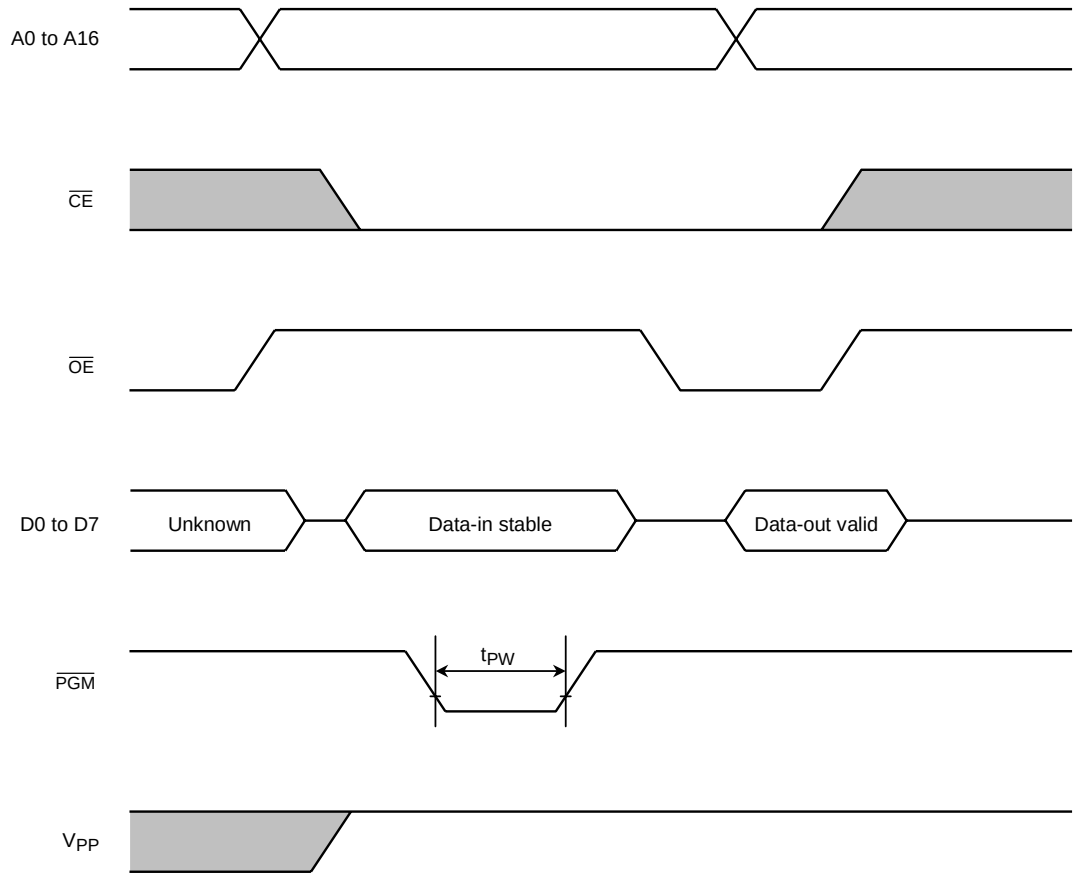
Ta = 25 ± 5°C, V_{CC} = 6.25 V ± 0.25 V

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Programming supply voltage	V_{PP}	–	12.50	12.75	13.00	V
Input high voltage (D0 to D7, A0 to A16, $\overline{CE}$, $\overline{OE}$, $\overline{PGM}$)	V_{IH}	–	2.6		V_{CC} + 0.3	V
Input low voltage (D0 to D7, A0 to A16, $\overline{CE}$, $\overline{OE}$, $\overline{PGM}$)	V_{IL}	–	–0.3		0.8	V
V_{CC} supply current	I_{CC}	fc = 10 MHz	–		50	mA
V_{PP} supply current	I_{PP}	V_{PP} = 13.00 V	–		50	mA
$\overline{PGM}$ program pulse width	t_{PW}	C_L = 50 pF	0.095	0.1	0.105	ms

4.12 Timing Chart of Read Operation in PROM Mode



4.13 Timing Chart of Program Operation in PROM Mode



Note 1: The power supply of V_{PP} (12.75 V) must be turned on at the same time or the later time for a power supply of V_{CC} and must be turned off at the same time or early time for a power supply of V_{CC}.

Note 2: The device suffers a damage taking out and putting in on the condition of V_{PP} = 12.75 V.

Note 3: The maximum spec of V_{PP} pin is 14.0 V. Be carefull a overshoot at the programming.

5. Package Dimensions

P-LQFP100-1414-0.50F

Unit: mm