

Section 15. Electrical Specifications

15.1 Absolute Maximum Ratings

Table 15-1 lists the absolute maximum ratings.

Table 15-1. Absolute Maximum Ratings

Item	Symbol	Rating	Unit
Supply voltage	V _{CC}	−0.3 to +7.0	V
Programming voltage	V _{PP}	−0.3 to +14.0	V
Input voltage	V _{in}	−0.3 to V _{CC} + 0.3	V
Operating temperature	T _{opr}	Regular specifications: −20 to +75	°C
		Wide-range specifications: −40 to +85	°C
Storage temperature	T _{stg}	−55 to +125	°C

Note: The input pins have protection circuits that guard against high static voltages and electric fields, but these high input-impedance circuits should never receive overvoltages exceeding the absolute maximum ratings shown in table 15-1.

15.2 Electrical Characteristics

15.2.1 DC Characteristics

Table 15-2 lists the DC characteristics of the H8/320 series.

Table 15-2. DC CharacteristicsConditions: $V_{CC} = 5.0V \pm 10\%$, $V_{SS} = 0V$, $T_a = -20$ to $75^\circ C$ (regular specifications) $T_a = -40$ to $85^\circ C$ (wide-range specifications)

						Measurement	
Item		Symbol	min	typ	max	Unit	conditions
Schmitt trigger	P66 – P63, P60,	V_{T^-}	1.0	–	–	V	
input voltage	P70	V_{T^+}	–	–	$V_{CC} \times 0.7$	V	
(1)		$V_{T^+} - V_{T^-}$	0.4	–	–	V	
Input high voltage	$\overline{RES}$, $\overline{STBY}$	V_{IH}	$V_{CC} - 0.7$	–	$V_{CC} + 0.3$	V	
(2)	MD1, MD0 EXTAL, $\overline{NMI}$						
Input high voltage	Input pins other than (1) and (2)	V_{IH}	2.0	–	$V_{CC} + 0.3$	V	
Input low voltage	$\overline{RES}$, $\overline{STBY}$	V_{IL}	–0.3	–	0.5	V	
(3)	MD1, MD0, EXTAL						
Input low voltage	Input pins other than (1) and (3)	V_{IL}	–0.3	–	0.8	V	
Output high	All output pins	V_{OH}	$V_{CC} - 0.5$	–	–	V	$I_{OH} = -200 \mu A$
voltage			3.5	–	–	V	$I_{OH} = -1.0 mA$
Output low	All output pins	V_{OL}	–	–	0.4	V	$I_{OL} = 1.6 mA$
voltage	P17 – P10, P27 – P20		–	–	1.0	V	$I_{OL} = 10.0 mA$
Input leakage	$\overline{RES}$	$ I_{in} $	–	–	10.0	μA	$V_{in} = 0.5 V$ to
current	$\overline{STBY}$, $\overline{NMI}$, MD1, MD0		–	–	1.0	μA	$V_{CC} - 0.5 V$
Leakage current	Ports 1 to 7	$ I_{TSI} $	–	–	1.0	μA	$V_{in} = 0.5 V$ to
in 3-state (off state)							$V_{CC} - 0.5 V$
Input pull-up	Ports 1 to 7	$-I_p$	30	–	250	μA	$V_{in} = 0 V$
MOS current							

Table 15-2. DC Characteristics (cont.)Conditions: $V_{CC} = AV_{CC} = 5.0V \pm 10\%$, $V_{SS} = 0V$, $T_a = -20$ to $75^\circ C$ (regular specifications) $T_a = -40$ to $85^\circ C$ (wide-range specifications)

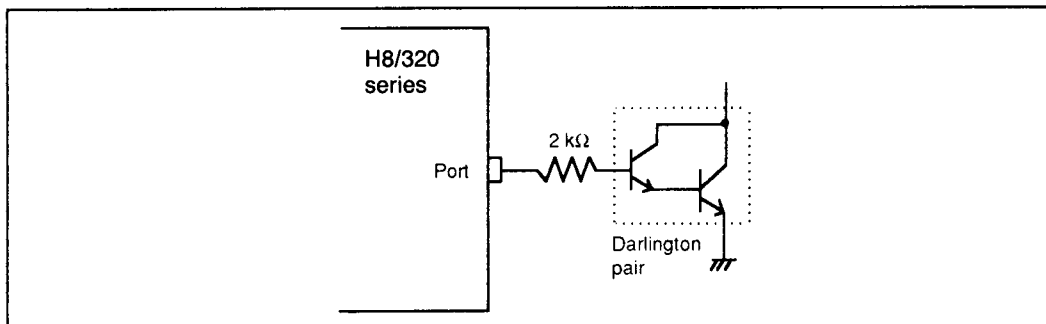
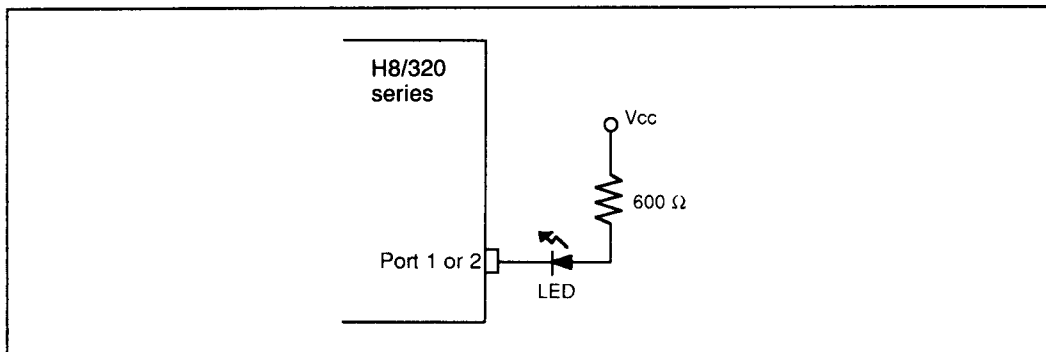
							Measurement
Item		Symbol	min	typ	max	Unit	conditions
Input capacitance	$\overline{RES}$	C_{in}	–	–	60	pF	$V_{in} = 0\text{ V}$
	$\overline{NMI}$		–	–	30	pF	
	All input pins		–	–	15	pF	$f = 1\text{ MHz}$
	except $\overline{RES}$ and $\overline{NMI}$						$T_a = 25^\circ\text{C}$
Current dissipation*	Normal operation	I_{CC}	–	12	25	mA	$f = 6\text{ MHz}$
			–	16	30	mA	$f = 8\text{ MHz}$
			–	20	40	mA	$f = 10\text{ MHz}$
	Sleep mode		–	8	15	mA	$f = 6\text{ MHz}$
			–	10	20	mA	$f = 8\text{ MHz}$
			–	12	25	mA	$f = 10\text{ MHz}$
	Standby modes		–	0.01	5.0	μA	
RAM standby voltage		V_{RAM}	2.0	–	–	V	

* Current dissipation values assume that $V_{IH \text{ min.}} = V_{CC} - 0.5V$, $V_{IL \text{ max.}} = 0.5V$, all output pins are in the no-load state, and all MOS input pull-ups are off.

Table 15-3. Allowable Output Current Sink ValuesConditions: $V_{CC} = 5.0V \pm 10\%$, $V_{SS} = 0V$, $T_a = -20$ to $75^\circ C$ (regular specifications) $T_a = -40$ to $85^\circ C$ (wide-range specifications)

Item		Symbol	min	typ	max	Unit
Allowable output low current sink (per pin)	Ports 1 and 2	I_{OL}	—	—	10	mA
	Other output pins		—	—	2.0	mA
Allowable output low current sink (total)	Ports 1 and 2, total	ΣI_{OL}	—	—	80	mA
	All output pins		—	—	120	mA
Allowable output high current sink (per pin)	All output pins	$-I_{OH}$	—	—	2.0	mA
	Total of all output	$\Sigma -I_{OH}$	—	—	40	mA
Allowable output high current sink (total)						

Note: To avoid degrading the reliability of the chip, be careful not to exceed the output current sink values in table 15-3. In particular, when driving a Darlington pair or LED directly, be sure to insert a current-limiting resistor in the output path. See figures 17-1 and 17-2.

**Figure 15-1. Example of Circuit for Driving a Darlington Pair****Figure 15-2. Example of Circuit for Driving a LED**

15.2.2 AC Characteristics

The AC characteristics for the H8/320 series are listed in three tables. Bus timing parameters are given in table 15-4, control signal timing parameters in table 15-5, and timing parameters of the on-chip supporting modules in table 15-6.

Table 15-4. Bus Timing

Conditions: $V_{CC} = 5.0V \pm 10\%$, $\phi = 0.5$ to 10MHz, $V_{SS} = 0V$,

$T_a = -20$ to $75^\circ C$ (regular specifications), $T_a = -40$ to $85^\circ C$ (wide-range specifications)

Measurement Item	Symbol	Measurement conditions	6MHz		8MHz		10MHz		Unit
			min	max	min	max	min	max	
Clock cycle time	t_{CYC}	Fig. 15-4	166.7	2000	125	2000	100	2000	ns
Clock pulse width Low	t_{CL}	Fig. 15-4	65	—	45	—	35	—	ns
Clock pulse width High	t_{CH}	Fig. 15-4	65	—	45	—	35	—	ns
Clock rise time	t_{Cr}	Fig. 15-4	—	15	—	15	—	15	ns
Clock fall time	t_{Cf}	Fig. 15-4	—	15	—	15	—	15	ns
Address delay time	t_{AD}	Fig. 15-4	—	70	—	60	—	55	ns
Address hold time	t_{AH}	Fig. 15-4	30	—	25	—	20	—	ns
Address strobe delay time	t_{ASD}	Fig. 15-4	—	70	—	60	—	40	ns
Write strobe delay time	t_{WSD}	Fig. 15-4	—	70	—	60	—	50	ns
Strobe delay time	t_{SD}	Fig. 15-4	—	70	—	60	—	50	ns
Write strobe pulse width	t_{WSW}	Fig. 15-4	200	—	150	—	120	—	ns
Address setup time 1	t_{AS1}	Fig. 15-4	25	—	20	—	15	—	ns
Address setup time 2	t_{AS2}	Fig. 15-4	105	—	80	—	65	—	ns
Read data setup time	t_{RDS}	Fig. 15-4	60	—	50	—	35	—	ns
Read data hold time	t_{RDH}	Fig. 15-4	0	—	0	—	0	—	ns
Write data delay time	t_{WDD}	Fig. 15-4	—	85	—	75	—	75	ns
Read data access time	t_{ACC}	Fig. 15-4	—	280	—	210	—	170	ns
Write data setup time	t_{WDS}	Fig. 15-4	30	—	15	—	10	—	ns
Write data hold time	t_{WDH}	Fig. 15-4	30	—	25	—	20	—	ns
Wait setup time	t_{WTS}	Fig. 15-5	45	—	45	—	45	—	ns
Wait hold time	t_{WTH}	Fig. 15-5	10	—	10	—	10	—	ns
E clock delay time	t_{ED}	Fig. 15-6	—	25	—	25	—	25	ns
E clock rise time	t_{Er}	Fig. 15-6	—	15	—	15	—	15	ns
E clock fall time	t_{Ef}	Fig. 15-6	—	15	—	15	—	15	ns
Read data hold time (for E clock)	t_{RDHE}	Fig. 15-6	0	—	0	—	0	—	ns
Write data hold time (for E clock)	t_{WDHE}	Fig. 15-6	50	—	40	—	30	—	ns

Table 15-5. Control Signal TimingConditions: $V_{CC} = 5.0V \pm 10\%$, $\emptyset = 0.5$ to 10 MHz, $V_{SS} = 0V$, $T_a = -20$ to $75^\circ C$ (regular specifications), $T_a = -40$ to $85^\circ C$ (wide-range specifications)

Measurement		Measurement conditions	6MHz		8MHz		10MHz		Unit
Item	Symbol		min	max	min	max	min	max	
RES setup time	tRESS	Fig. 15-7	200	—	200	—	200	—	ns
RES pulse width	tRESW	Fig. 15-7	10	—	10	—	10	—	t _{cy}
Mode programming setup time	tMDS	Fig. 15-7	4	—	4	—	4	—	t _{cy}
NMI setup time ($\overline{NMI}$, $\overline{IRQ_0}$ to $\overline{IRQ_2}$)	tNMIS	Fig. 15-8	150	—	150	—	150	—	ns
NMI hold time ($\overline{NMI}$, $\overline{IRQ_0}$ to $\overline{IRQ_2}$)	tNMIH	Fig. 15-8	10	—	10	—	10	—	ns
Interrupt pulse width for recovery from software standby mode ($\overline{NMI}$, $\overline{IRQ_0}$ to $\overline{IRQ_2}$)	tNMIW	Fig. 15-8	200	—	200	—	200	—	ns
Crystal oscillator settling time (reset)	tOSC1	Fig. 15-9	20	—	20	—	20	—	ms
Crystal oscillator settling time (software standby)	tOSC2	Fig. 15-10	10	—	10	—	10	—	ms

Table 15-6. Timing Conditions of On-Chip Supporting ModulesConditions: $V_{CC} = 5.0V \pm 10\%$, $\emptyset = 0.5$ to 10MHz, $V_{SS} = 0V$, $T_a = -20$ to $75^\circ C$ (regular specifications), $T_a = -40$ to $85^\circ C$ (wide-range specifications)

		Measurement conditions	6MHz		8MHz		10MHz		Unit
Item	Symbol		min	max	min	max	min	max	
FRT Timer output delay time	tFTOD	Fig. 15-11	—	100	—	100	—	100	ns
Timer input setup time	tFTIS	Fig. 15-11	50	—	50	—	50	—	ns
Timer clock input setup time	tFTCS	Fig. 15-12	50	—	50	—	50	—	ns
Timer clock pulse width	tFTCWH tFTCWL	Fig. 15-12	1.5	—	1.5	—	1.5	—	t _{cy}

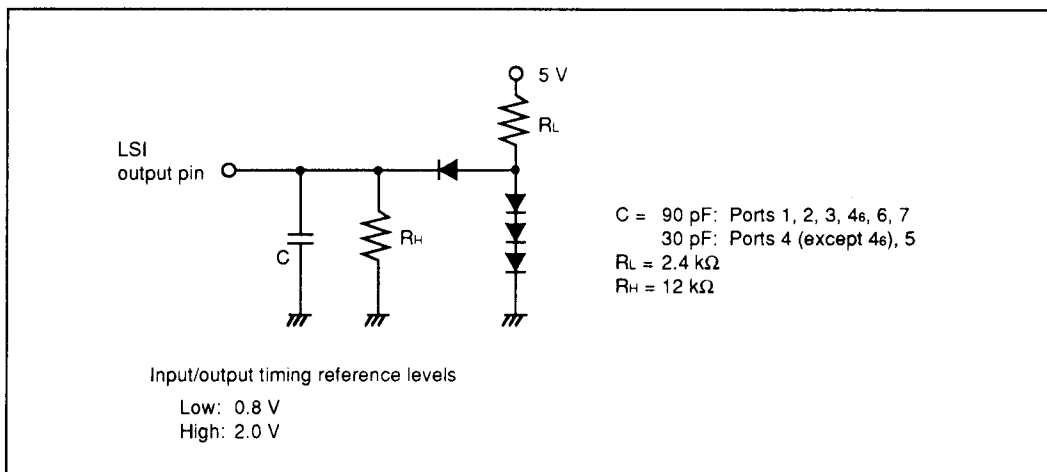
Table 15-6. Timing Conditions of On-Chip Supporting Modules (cont.)Conditions: $V_{CC} = 5.0V \pm 10\%$, $\phi = 0.5$ to 10 MHz, $V_{SS} = 0V$, $T_a = -20$ to $75^\circ C$ (regular specifications), $T_a = -40$ to $85^\circ C$ (wide-range specifications)

Item	Symbol	Measurement conditions	6MHz		8MHz		10MHz		Unit
			min	max	min	max	min	max	
TMR	Timer output delay time	tTMOD Fig. 15-13	–	100	–	100	–	100	ns
	Timer reset input setup time	tTMRS Fig. 15-15	50	–	50	–	50	–	ns
	Timer clock input setup time	tTMCS Fig. 15-14	50	–	50	–	50	–	ns
	Timer clock pulse width (single edge)	tTMCWH tTMCWL Fig. 15-14	1.5	–	1.5	–	1.5	–	t _{cyc}
	Timer clock pulse width (both edges)	Fig. 15-14	2.5	–	2.5	–	2.5	–	t _{cyc}
	Input (Async) clock cycle	tS _{cyc} Fig. 15-16	2	–	2	–	2	–	t _{cyc}
	clock (Sync) cycle	tS _{cyc} Fig. 15-16	4	–	4	–	4	–	t _{cyc}
SCI	Transmit data delay time (Sync)	tTXD Fig. 15-16	–	100	–	100	–	100	ns
	Receive data setup time (Sync)	tRXS Fig. 15-16	100	–	100	–	100	–	ns
	Receive data hold time (Sync)	tRXH Fig. 15-16	100	–	100	–	100	–	ns
	Input clock pulse width	tSCKW Fig. 15-17	0.4	0.6	0.4	0.6	0.4	0.6	t _{S_{cyc}}
	Output data delay time	tPWD Fig. 15-18	–	100	–	100	–	100	ns
Ports	Input data setup time	tPRS Fig. 15-18	50	–	50	–	50	–	ns
	Input data hold time	tPRII Fig. 15-18	50	–	50	–	50	–	ns

Table 15-6. Timing Conditions of On-Chip Supporting Modules (cont.)Conditions: $V_{CC} = 5.0V \pm 10\%$, $\phi = 0.5$ to 10 MHz, $V_{SS} = 0V$, $T_a = -20$ to 75°C (regular specifications), $T_a = -40$ to 85°C (wide-range specifications)

	Item	Symbol	Measurement conditions	6MHz		8MHz		10MHz		Unit
				min	max	min	max	min	max	
Parallel handshake interface	Handshake input strobe pulse width	t_{HISW}	Fig. 15-19	1.5	—	1.5	—	1.5	—	t_{cyc}
	Handshake input data setup time	t_{HIS}	Fig. 15-19	10	—	10	—	10	—	ns
	Handshake input data hold time	t_{HIH}	Fig. 15-19	120	—	120	—	120	—	ns
	Handshake output strobe delay time	t_{HOSD1}	Fig. 15-20	—	80	—	80	—	80	ns
	Handshake output strobe delay time	t_{HOSD2}	Fig. 15-20	—	80	—	80	—	80	ns
	Busy output delay time	t_{HBSOD1}	Fig. 15-21	—	150	—	150	—	150	ns
	Busy output delay time	t_{HBSOD2}	Fig. 15-21	—	150	—	150	—	150	ns

• Measurement Conditions for AC Characteristics

**Figure 15-3. Output Load Circuit**

15.3 MCU Operational Timing

This section provides the following timing charts:

15.3.1 Bus Timing	Figures 15-4 to 15-6
15.3.2 Control Signal Timing	Figures 15-7 to 15-10
15.3.3 16-Bit Free-Running Timer Timing	Figures 15-11 to 15-12
15.3.4 8-Bit Timer Timing	Figures 15-13 to 15-15
15.3.6 SCI Timing	Figures 15-15 to 15-17
15.3.7 I/O Port Timing	Figure 15-18
15.3.8 Parallel Handshaking Interface Timing	Figures 15-19 to 15-21

15.3.1 Bus Timing

(1) Basic Bus Cycle (without Wait States) in Expanded Modes

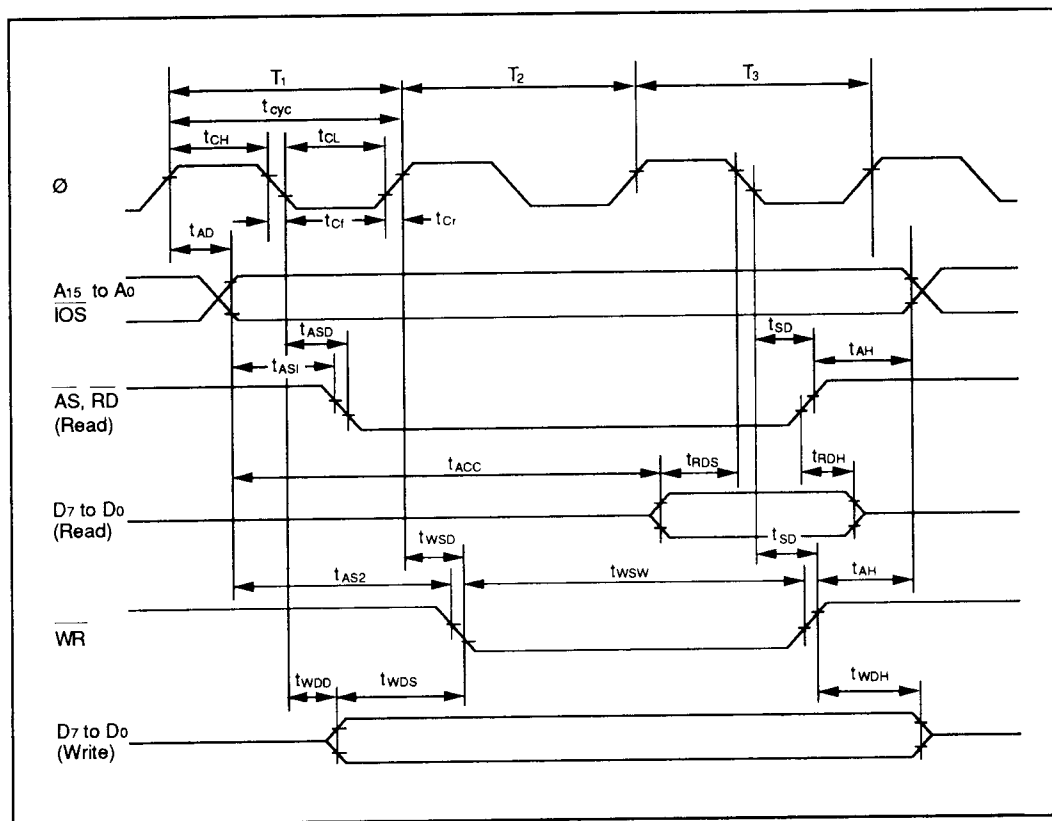


Figure 15-4. Basic Bus Cycle (without Wait States) in Expanded Modes

(2) Basic Bus Cycle (with 1 Wait State) in Expanded Modes

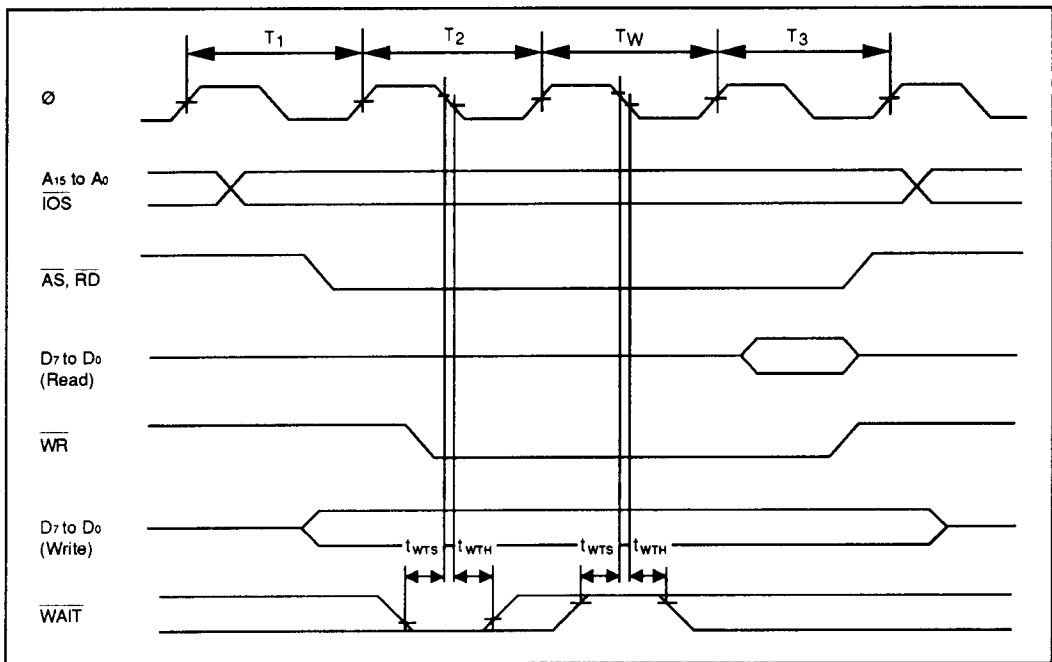


Figure 15-5. Basic Bus Cycle (with 1 Wait State) in Expanded Modes

(3) E Clock Bus Cycle

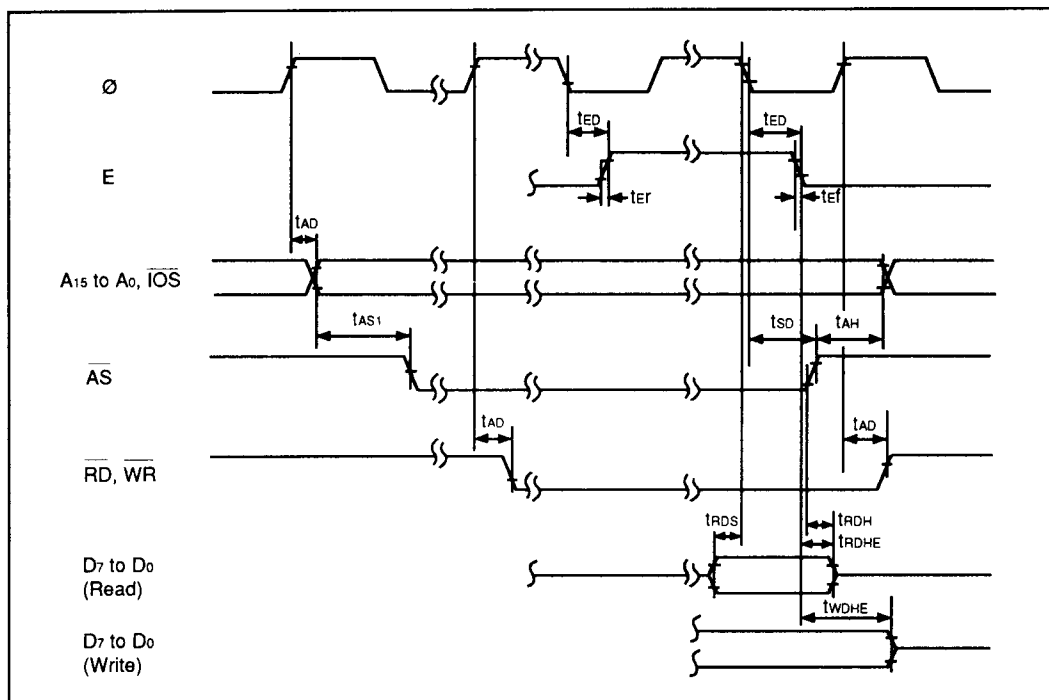


Figure 15-6. E Clock Bus Cycle

15.3.2 Control Signal Timing

(1) Reset Input Timing

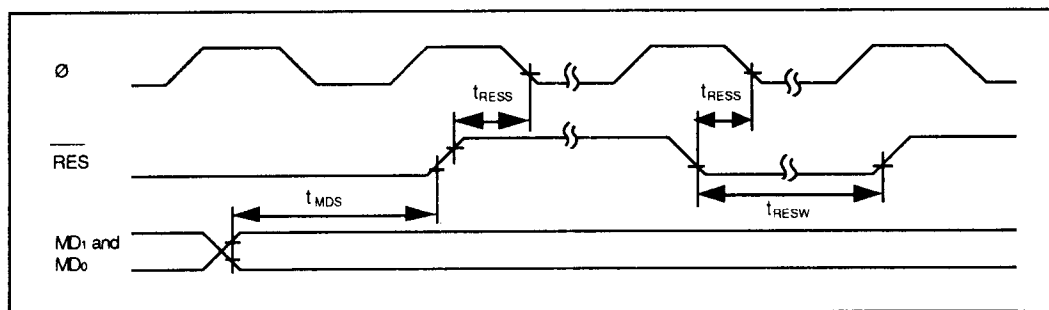


Figure 15-7. Reset Input Timing

(2) Interrupt Input Timing

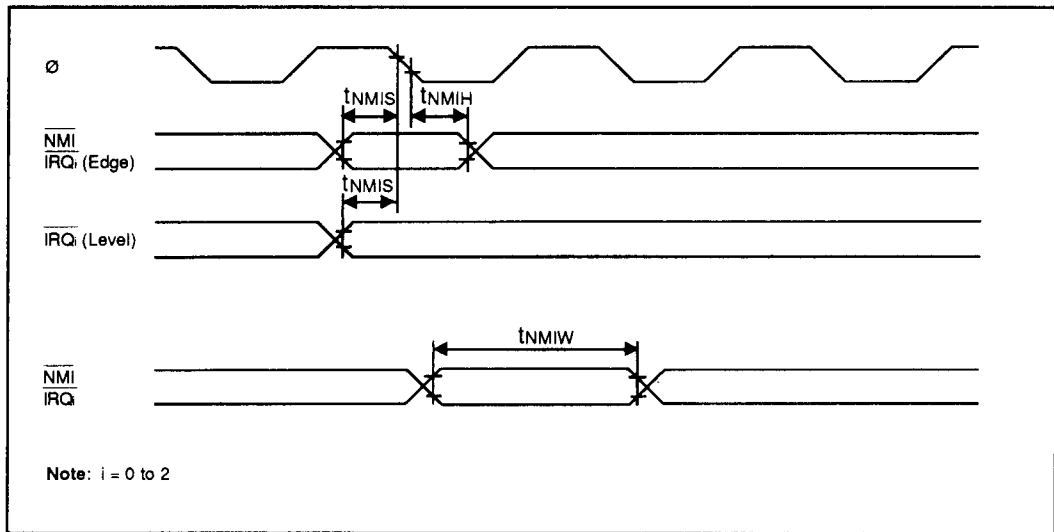


Figure 15-8. Interrupt Input Timing

(3) Clock Settling Timing

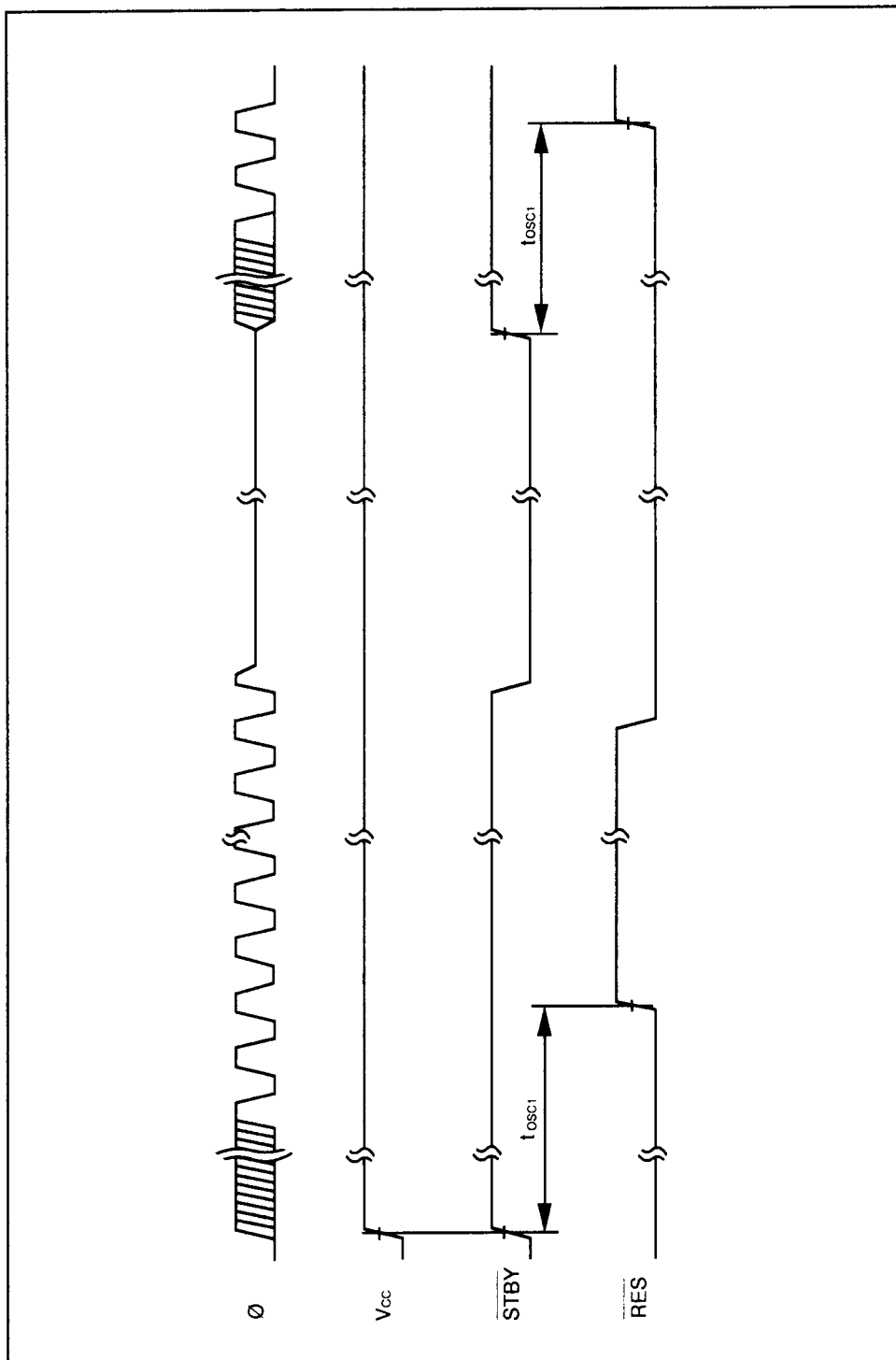


Figure 15-9. Clock Settling Timing

(4) Clock Settling Timing for Recovery from Software Standby Mode

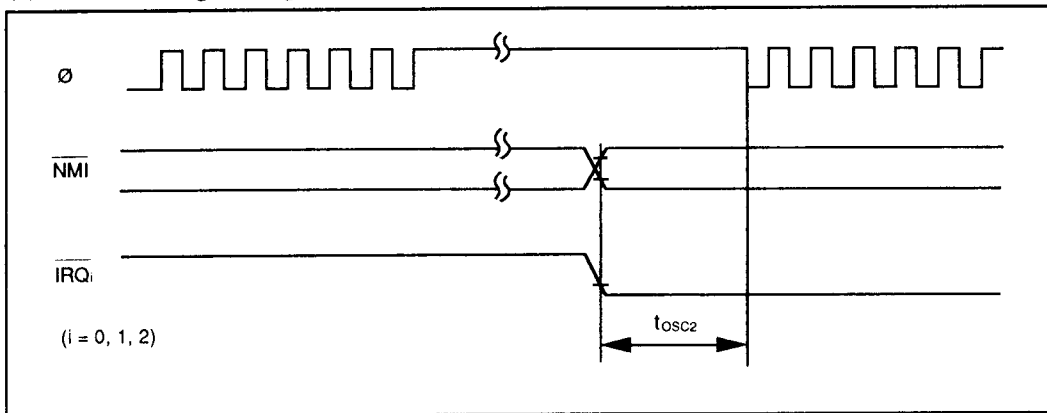


Figure 15-10. Clock Settling Timing for Recovery from Software Standby Mode

15.3.3 16-Bit Free-Running Timer Timing

(1) Free-Running Timer Input/Output Timing

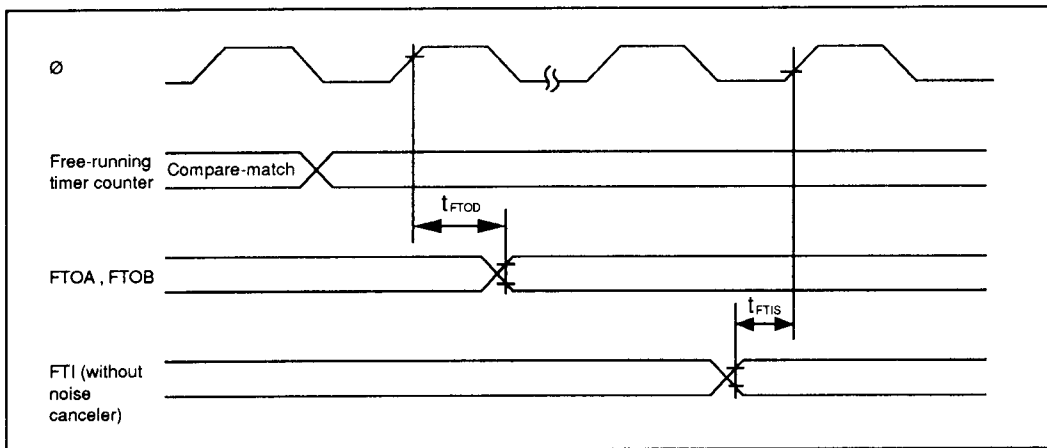


Figure 15-11. Free-Running Timer Input/Output Timing

(2) External Clock Input Timing for Free-Running Timer

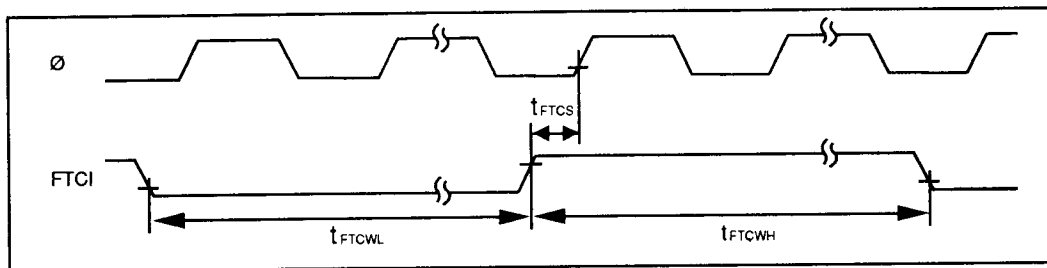


Figure 15-12. External Clock Input Timing for Free-Running Timer

15.3.4 8-Bit Timer Timing

(1) 8-Bit Timer Output Timing

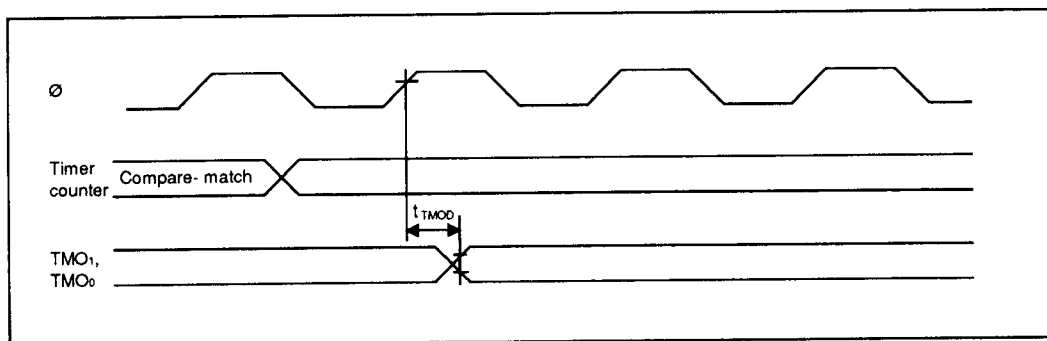


Figure 15-13. 8-Bit Timer Output Timing

(2) 8-Bit Timer Clock Input Timing

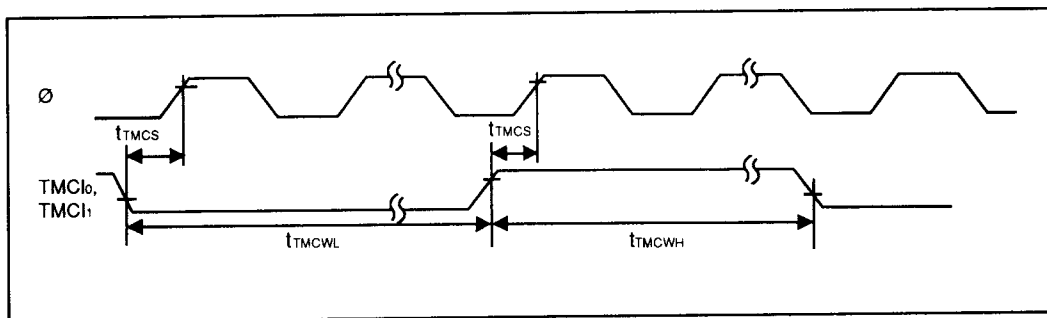


Figure 15-14. 8-Bit Timer Clock Input Timing

(3) 8-Bit Timer Reset Input Timing

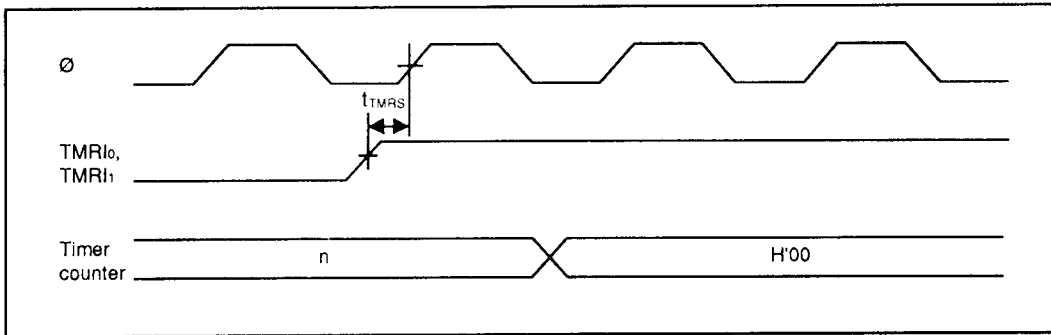


Figure 15-15. 8-Bit Timer Reset Input Timing

15.3.5 Serial Communication Interface Timing

(1) SCI Input/Output Timing

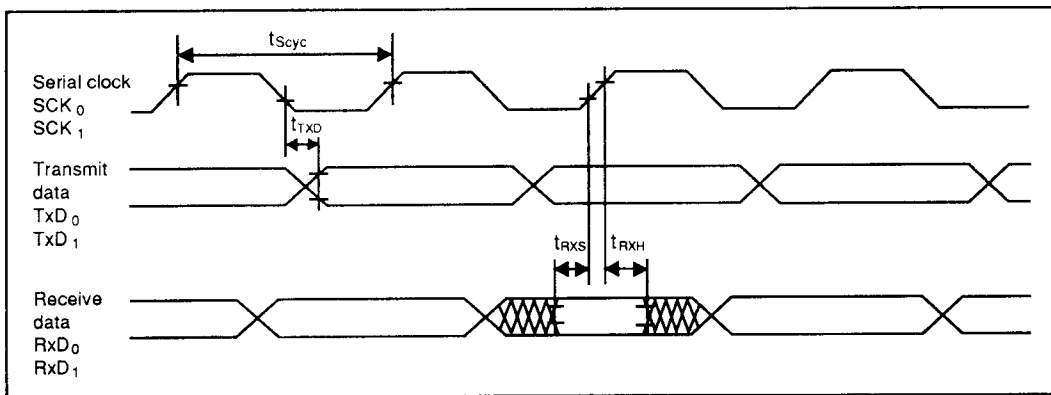


Figure 15-16. SCI Input/Output Timing (Synchronous Mode)

(2) SCI Input Clock Timing

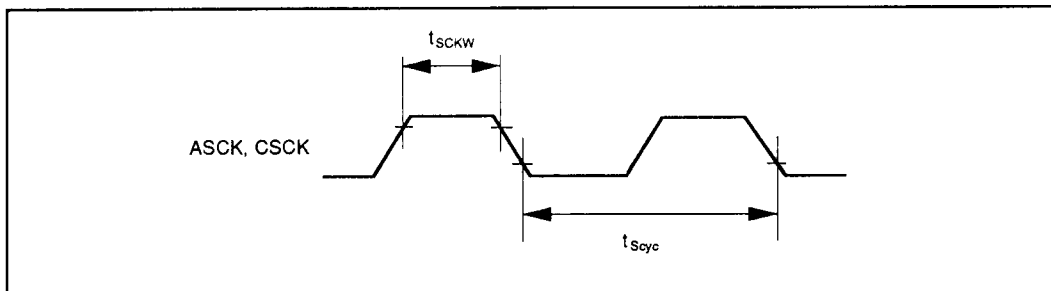


Figure 15-17. SCI Input Clock Timing

15.3.6 I/O Port Timing

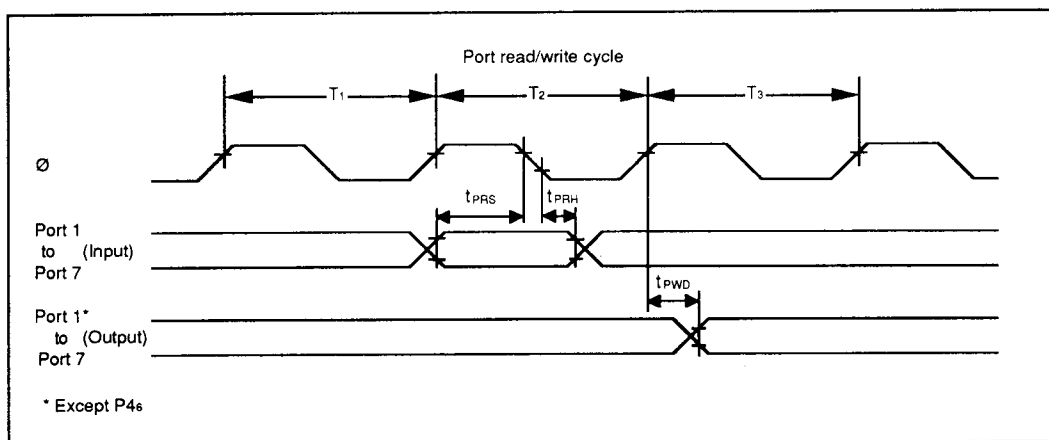


Figure 15-18. I/O Port Input/Output Timing

15.3.7 Parallel Handshake Interface Timing

(1) Input Strobe Input Timing

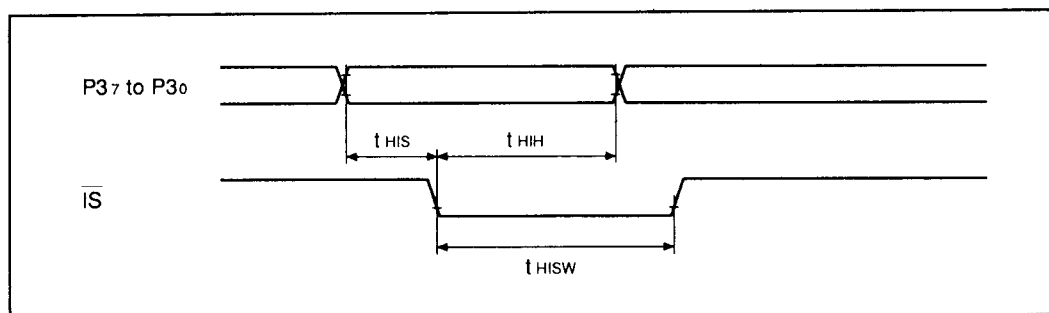


Figure 15-19. Input Strobe Input Timing

(2) Output Strobe Output Timing

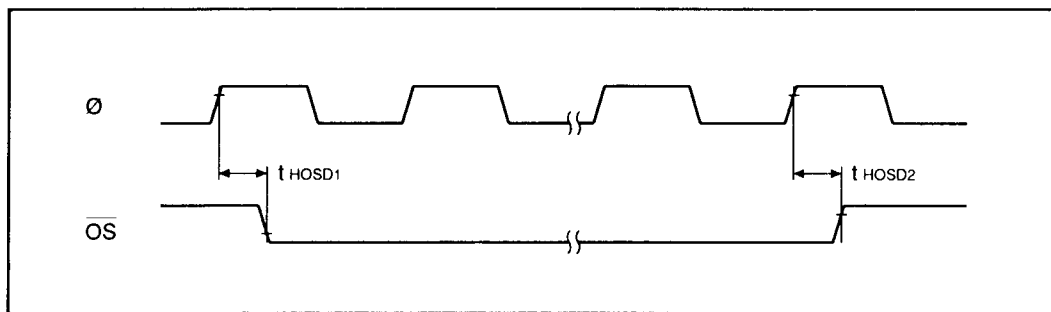


Figure 15-20. Output Strobe Output Timing

(3) Busy Output Timing

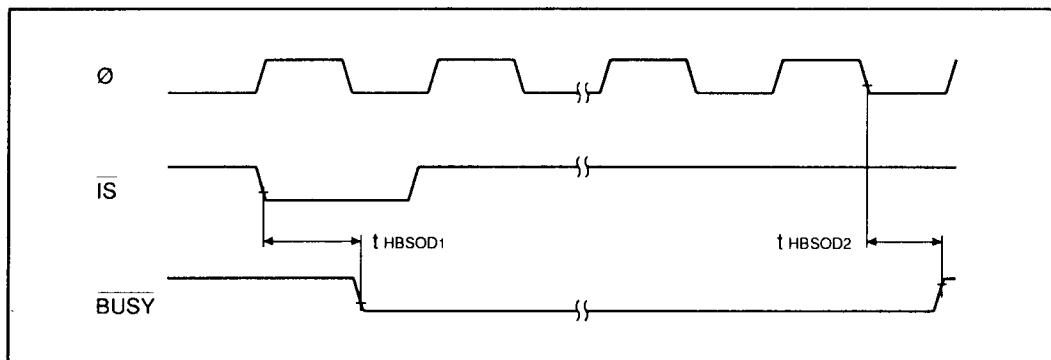


Figure 15-21. Busy Output Timing

Table C-1. Pin States (cont.)

T-90-01

Pin Name	MCU Mode	Reset	Hardware Standby	Software Standby	Sleep Mode	Normal Operation
P55 to P50,	1	3-State	3-State	Prev. state	Prev. state	I/O port
	2			(note 3)		
	3					
P66 to P60,	1	3-State	3-State	Prev. state	Prev. state	I/O port
	2			(note 3)		
	3					
P77/ $\overline{\text{WAIT}}$	1	3-State	3-State	3-state	3-state	$\overline{\text{WAIT}}$
	2					
	3			Prev. state	Prev. state	I/O port
P76 to P74,	1	High	3-State	High	High	$\overline{\text{AS}}$, $\overline{\text{WR}}$,
$\overline{\text{AS}}$, $\overline{\text{WR}}$, $\overline{\text{RD}}$,	2					$\overline{\text{RD}}$
	3	3-State		Prev. state	Prev. state	I/O port
P73 to P70,	1	3-State	3-State	Prev. state	Prev. state	I/O port
	2					
	3					

Notes:

1. 3-state: High-impedance state
2. Prev. state: Previous state. Input ports are in the high-impedance state (with the MOS pull-up on if DDR = 0 and DR = 1). Output ports hold their previous output level.
3. On-chip supporting modules are initialized, so these pins revert to I/O ports according to the DDR and DR bits.
4. I/O port: Direction depends on the data direction (DDR) bit. Note that these pins may also be used by the on-chip supporting modules.

See section 5, I/O Ports for further information.

Appendix D. Package Dimensions

T-90-20

Figure D-1 shows the dimensions of the DC-64S package. Figure D-2 shows the dimensions of the DP-64S package. Figure D-3 shows the dimensions of the FP-64A package.

Unit: mm (inch)

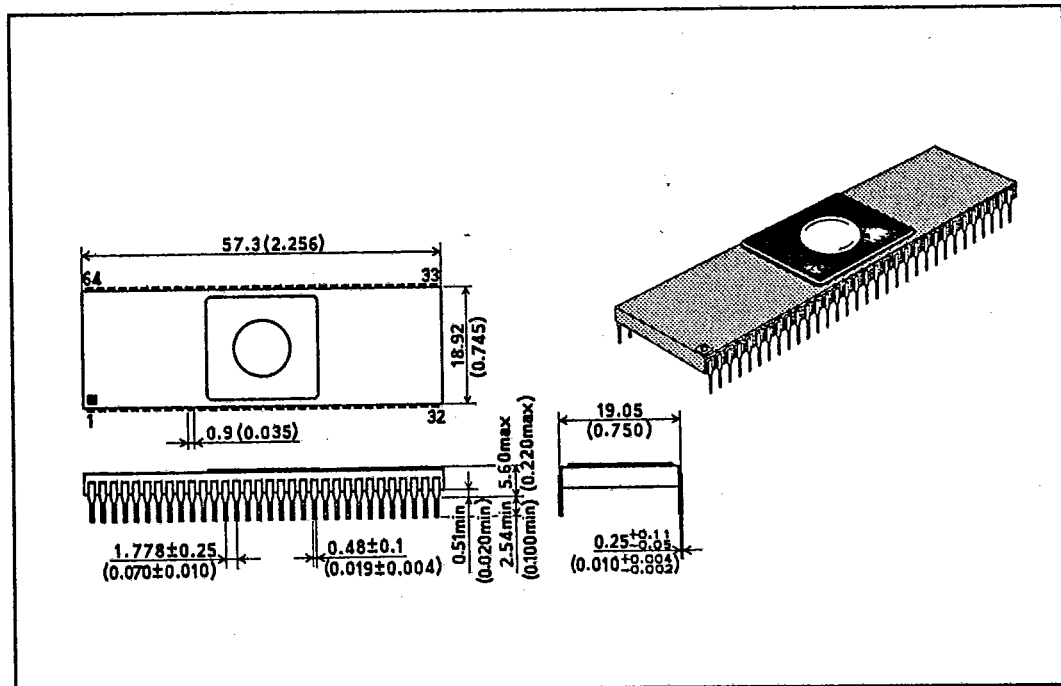


Figure D-1. Package Dimensions (DC-64S)

Unit: mm (inch)

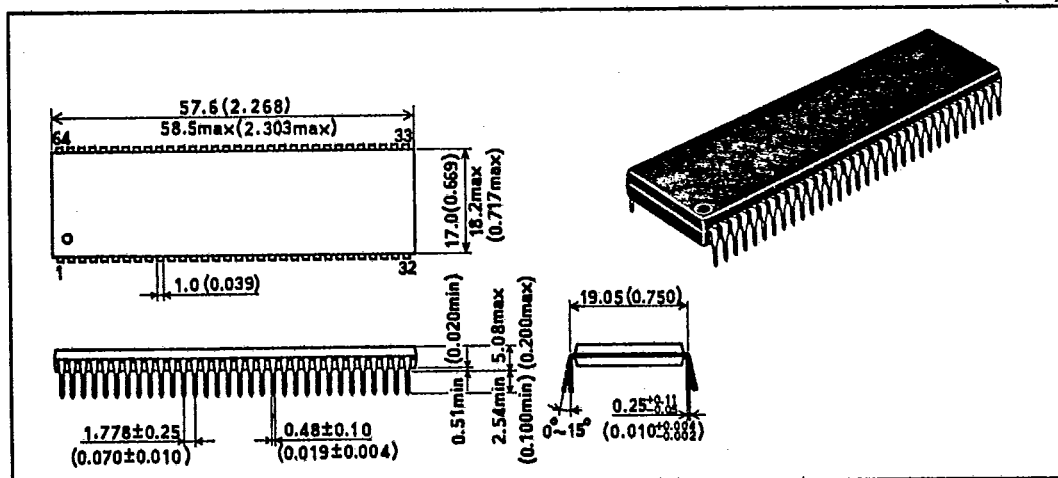


Figure D-2. Package Dimensions (DP-64S)

Appendix E. Package Dimensions

T-90-20

Figure D-1 shows the dimensions of the DC-64S package. Figure D-2 shows the dimensions of the DP-64S package. Figure D-3 shows the dimensions of the FP-64A package. Figure D-4 shows the dimensions of the CP-68 package.

Unit: mm

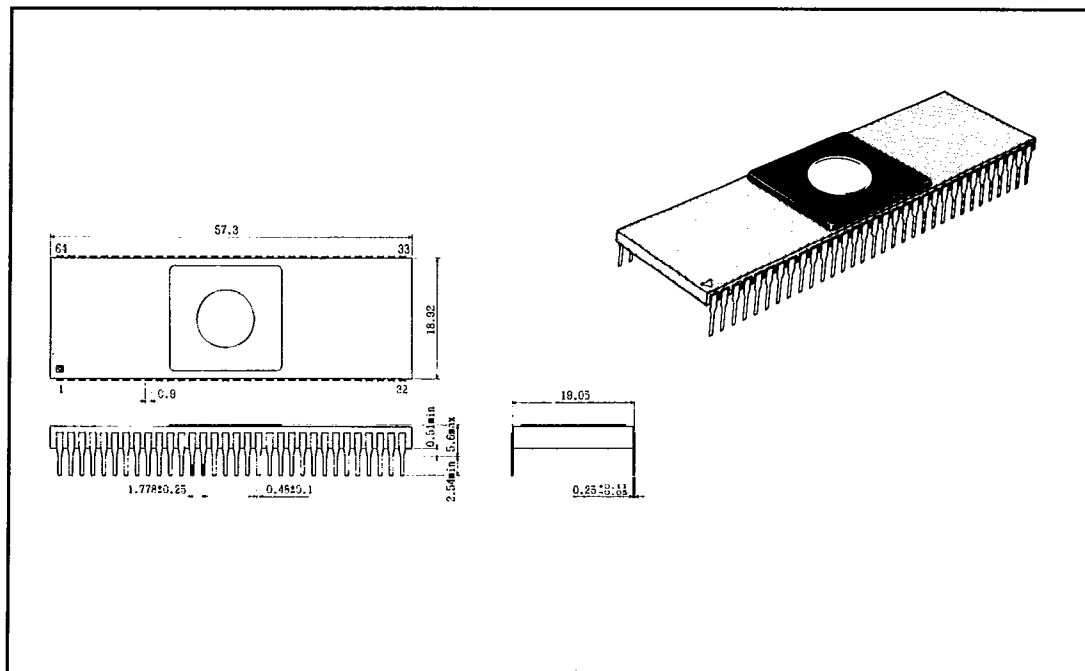


Figure E-1. Package Dimensions (DC-64S)

Unit: mm

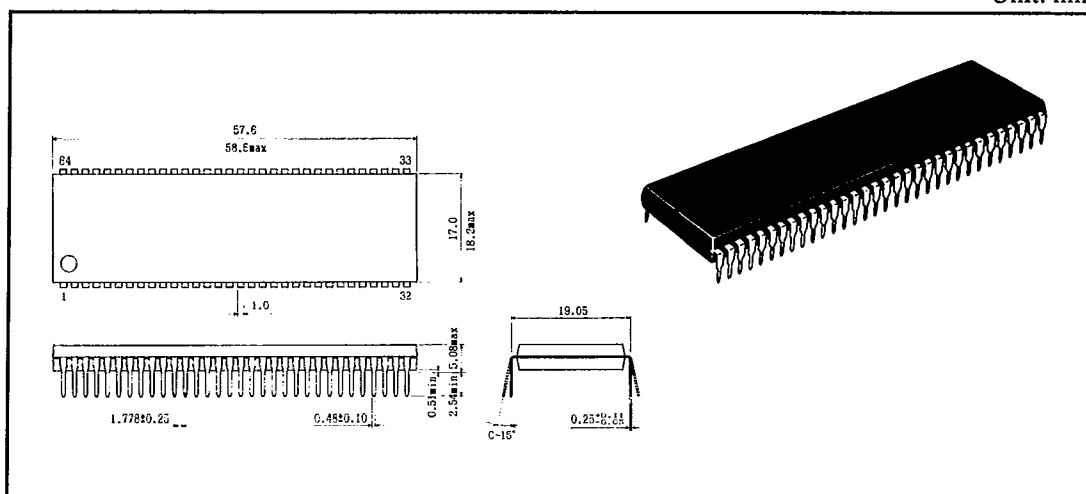


Figure E-2. Package Dimensions (DP-64S)

Unit: mm

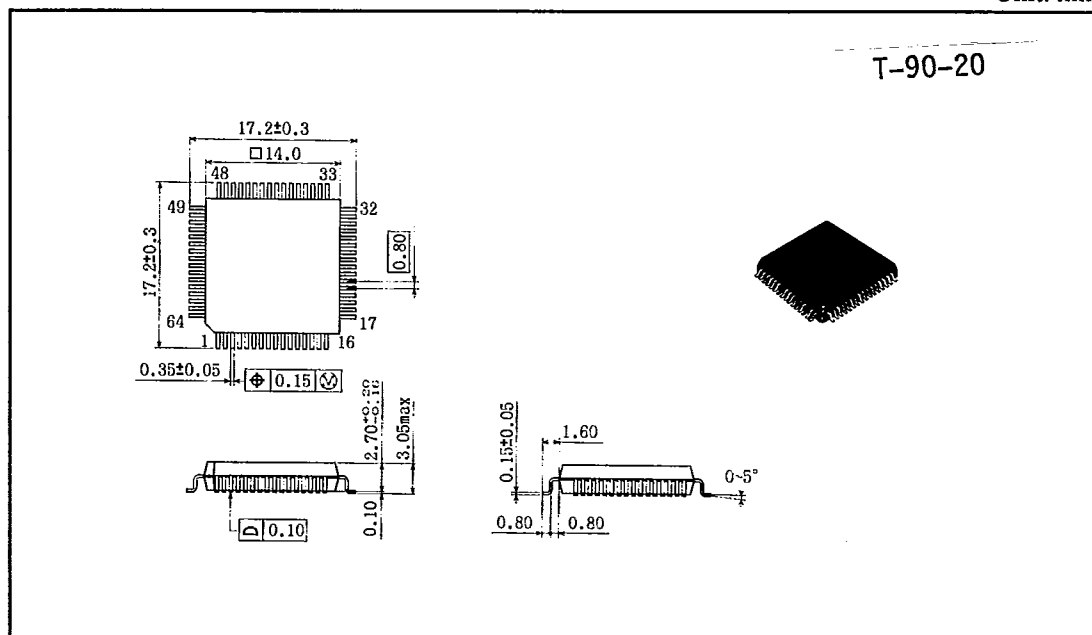


Figure E-3. Package Dimensions (FP-64A)

Unit: mm

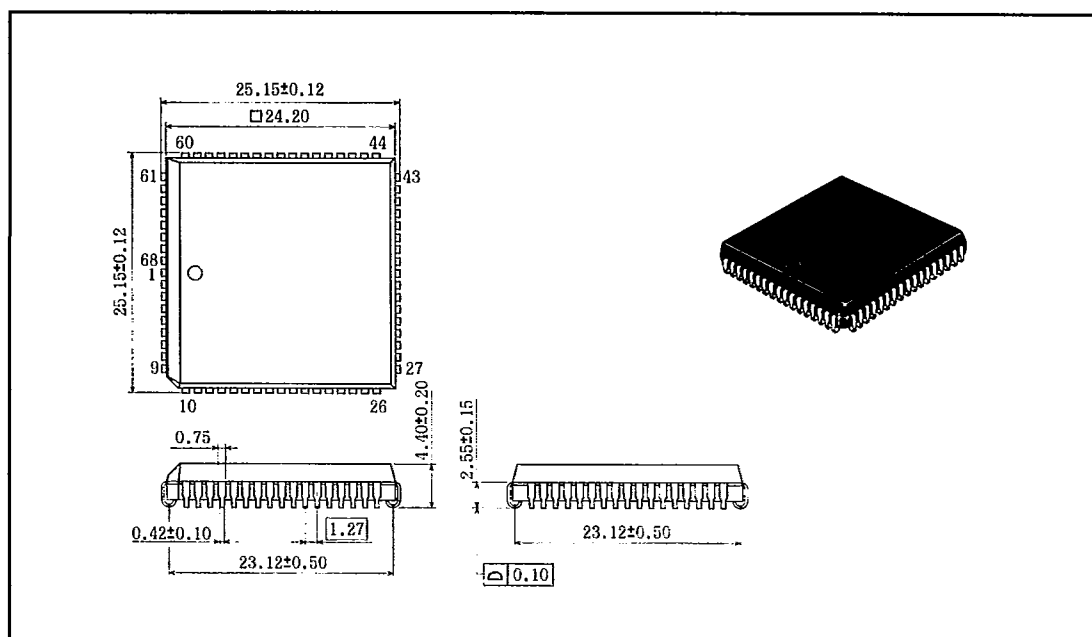


Figure E-4. Package Dimensions (CP-68)