

Section 18 Electrical Specifications

18.1 Absolute Maximum Ratings

Table 18-1 lists the absolute maximum ratings.

Table 18-1 Absolute Maximum Ratings

Item	Symbol	Rating	Unit
Supply voltage	V _{CC}	−0.3 to +0.7	V
Programming voltage	V _{PP}	−0.3 to +13.5	V
Input voltage (except port 6)	V _{in}	−0.3 to V _{CC} + 0.3	V
Input voltage (port 6)	V _{in}	−0.3 to AV _{CC} + 0.3	V
Analog supply voltage	AV _{CC}	−0.3 to +7.0	V
Analog input voltage	VA _N	−0.3 to AV _{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: Permanent damage to the chip may result if the absolute maximum ratings shown in table 18-1 are exceeded.

18.2 Electrical Characteristics

18.2.1 DC Characteristics

Table 18-2 lists the DC characteristics.

Table 18-2 DC CharacteristicsConditions: $V_{CC} = AV_{CC} = 5.0 \text{ V} \pm 10\%^{*1}$, $V_{SS} = AV_{SS} = 0 \text{ V}$, $T_a = -20 \text{ to } 75^\circ\text{C}$ (Regular specifications) $T_a = -40 \text{ to } 85^\circ\text{C}$ (Wide-range specifications)

Item		Symbol	min	typ	max	Unit	Test Conditions
Input high voltage	RES, MD2, MD1, MD0	V_{IH}	$V_{CC} - 0.7$	—	$V_{CC} + 0.3$	V	
	EXTAL		$V_{CC} \times 0.7$	—	$V_{CC} + 0.3$	V	
	Port 6		2.2	—	$AV_{CC} + 0.3$	V	
	Other input pins (except port 5)		2.2	—	$V_{CC} + 0.3$	V	
Input low voltage	RES, MD2, MD1, MD0	V_{IL}	-0.3	—	0.5	V	
	Other input pins (except port 5)		-0.3	—	0.8		
Schmitt trigger input voltage	Port 5	V_{T-}	1.0	—	2.5	V	
		V_{T+}	2.0	—	3.5	V	
		$V_{T+} - V_{T-}$	0.4	—	—	V	
Input leakage current	RES	$ I_{in} $	—	—	10.0	μA	$V_{in} = 0.5 \text{ to}$ $V_{CC} - 0.5 \text{ V}$
	NMI, MD2, MD1, MD0,		—	—	1.0	μA	
	Port 6		—	—	1.0	μA	$V_{in} = 0.5 \text{ to}$ $AV_{CC} - 0.5 \text{ V}$
Leakage current in 3-state (off state)	Port 7, ports 5 to 1	$ I_{TSI} $	—	—	1.0	μA	$V_{in} = 0.5 \text{ to}$ $V_{CC} - 0.5 \text{ V}$
Input pull-up MOS current	Ports 3 and 4	$-I_P$	50	—	200	μA	$V_{in} = 0 \text{ V}$
Output high voltage	All output pins	V_{OH}	$V_{CC} - 0.5$	—	—	V	$I_{OH} = -200 \mu\text{A}$
			3.5	—	—	V	$I_{OH} = -1 \text{ mA}$
Output low voltage	All output pins (except RES)	V_{OL}	—	—	0.4	V	$I_{OL} = 1.6 \text{ mA}$
	Port 3		—	—	1.0	V	$I_{OL} = 8 \text{ mA}$
			—	—	1.2	V	$I_{OL} = 10 \text{ mA}$
	RES		—	—	0.4	V	$I_{OL} = 2.6 \text{ mA}$
Input capacitance	RES	C_{in}	—	—	60	pF	$V_{in} = 0 \text{ V}$
	NMI		—	—	30	pF	$f = 1 \text{ MHz}$
	All input pins except RES		—	—	15	pF	$T_a = 25^\circ\text{C}$

Table 18-2 DC Characteristics (cont)

		Symbol					Test
Item			min	typ	max	Unit	Conditions
Current dissipation*	Normal operation	I _{cc}	—	20	30	mA	f = 6 MHz
			—	25	40	mA	f = 8 MHz
			—	30	50	mA	f = 10 MHz
			—	12	20	mA	f = 6 MHz
	Sleep mode		—	16	25	mA	f = 8 MHz
			—	20	30	mA	f = 10 MHz
	Standby		—	0.01	5.0	μA	
Analog supply current	During A/D conversion	A _{Icc}	—	0.6	2.0	mA	
	While waiting		—	0.01	5.0	μA	
RAM standby voltage		V _{RAM}	2.0	—	—	V	

Note: AV_{CC} must be connected to a power supply even when the A/D converter is not used.

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

Table 18-3 Allowable Output Current Sink Values

Conditions: V_{CC} = AV_{CC} = 5.0 V ± 10%, V_{SS} = AV_{SS} = 0 V,

T_a = –20 to 75°C (Regular specifications)

T_a = –40 to 85°C (Wide-range specifications)

Item		Symbol	min	typ	max	Unit
Allowable output low current sink (per pin)	Port 3	I _{OL}	—	—	10	mA
	RES		—	—	2.6	mA
	Other output pins		—	—	2.0	mA
Allowable output low current sink (total)	Port 3, total of 8 pins	Σ I _{OL}	—	—	40	mA
	Total of all other output pins		—	—	80	mA
Allowable output high current sink (per pin)	All output pins	–I _{OH}	—	—	2.0	mA
Allowable output high current sink (total)	Total of all output pins	Σ –I _{OH}	—	—	40	mA

Note: To avoid degrading the reliability of the chip, be careful not to exceed the output current sink values in table 18-3. In particular, when driving a Darlington transistor pair or LED directly, be sure to insert a current-limiting resistor in the output path. See figures 18-1 and 18-2.

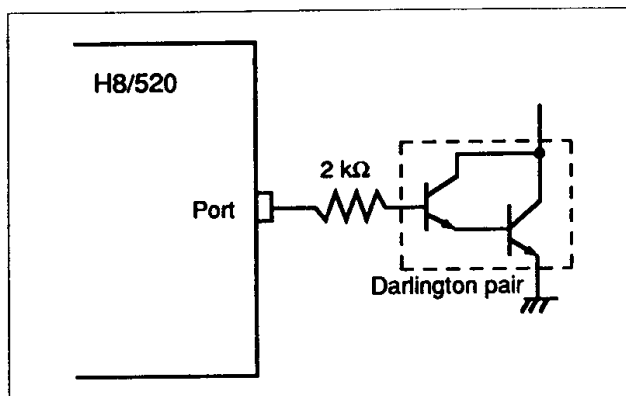


Figure 18-1 Example of Circuit for Driving a Darlington Transistor Pair

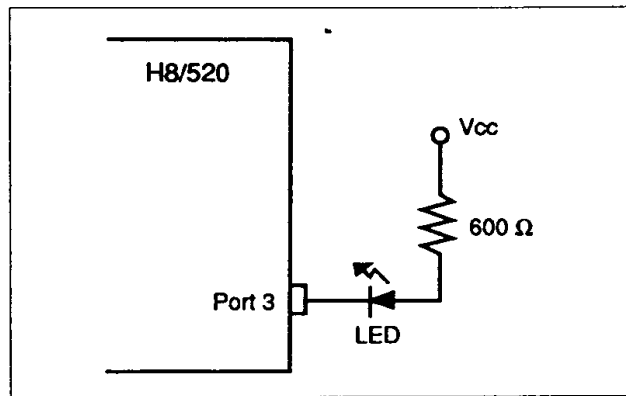


Figure 18-2 Example of Circuit for Driving an LED

18.2.2 AC Characteristics

The AC characteristics of the H8/520 chip are listed in three tables. Bus timing parameters are given in table 18-4, control signal timing parameters in table 18-5, and timing parameters of the on-chip supporting modules in table 18-6. See figure 18-3 for the output load circuit.

Table 18-4 Bus Timing

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

$T_a = -20$ to 75°C (Regular specifications)

$T_a = -40$ to 85°C (Wide-range specifications)

Item	Symbol	6 MHz		8 MHz		10 MHz		Unit	Test Conditions
		min	max	min	max	min	max		
Clock cycle time	t_{cyc}	166.7	2000	125	2000	100	2000	ns	See figure 18-4
Clock pulse width low	t_{CL}	65	—	45	—	35	—	ns	
Clock pulse width high	t_{CH}	65	—	45	—	35	—	ns	
Clock rise time	t_{Cr}	—	15	—	15	—	15	ns	
Clock fall time	t_{Cf}	—	15	—	15	—	15	ns	
Address delay time	t_{AD}	—	70	—	60	—	55	ns	See figure 18-4
Address hold time	t_{AH}	30	—	25	—	20	—	ns	
RD delay time 1	t_{RDD1}	—	70	—	60	—	40	ns	
RD delay time 2	t_{RDD2}	—	70	—	60	—	50	ns	
WR delay time 1	t_{WRD1}	—	70	—	60	—	50	ns	
WR delay time 2	t_{WRD2}	—	70	—	60	—	50	ns	
Write data strobe pulse width	t_{DSWW}	200	—	150	—	120	—	ns	
Address setup time 1	t_{AS1}	25	—	20	—	15	—	ns	
Address setup time 2	t_{AS2}	105	—	80	—	65	—	ns	
Read data setup time	t_{RDS}	60	—	50	—	40	—	ns	

Table 18-4 Bus Timing (cont)

Item	Symbol	6 MHz		8 MHz		10 MHz		Test	
		min	max	min	max	min	max	Unit	Conditions
Read data hold time	tRDH	0	—	0	—	0	—	ns	See figure 18-4
Read data access time	tACC	—	280	—	190	—	160	ns	
Write data delay time	tWDD	—	70	—	60	—	60	ns	
Write data setup time	tWDS	30	—	15	—	10	—	ns	
Write data hold time	tWDH	30	—	25	—	20	—	ns	
Wait setup time	tWTS	40	—	40	—	40	—	ns	See figure 18-5
Wait hold time	tWTH	10	—	10	—	10	—	ns	

Table 18-5 Control Signal Timing

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

$T_a = -20$ to 75°C (Regular specifications)

$T_a = -40$ to 85°C (Wide-range specifications)

Item	Symbol	6 MHz		8 MHz		10 MHz		Test	
		min	max	min	max	min	max	Unit	Conditions
RES setup time	tRESS	200	—	200	—	200	—	ns	See figure 18-6
RES pulse width 1*	tRESW1	6.0	—	6.0	—	6.0	—	t _{cy}	
RES pulse width 2*	tRESW2	520	—	520	—	520	—	t _{cy}	
RES output delay time	tRESO	—	100	—	100	—	100	ns	See figure 18-7
RES output pulse width	tRESOW	132	—	132	—	132	—	t _{cy}	
Mode programming setup time	tMDS	4.0	—	4.0	—	4.0	—	t _{cy}	See figure 18-6
NMI setup time	tNMIS	150	—	150	—	150	—	ns	See figure 18-8
NMI hold time	tNMIH	10	—	10	—	10	—	ns	
IRQ ₀ setup time	tIRQ0S	50	—	50	—	50	—	ns	
IRQ ₁ to IRQ ₇ setup time	tIRQ1S	50	—	50	—	50	—	ns	
IRQ ₁ to IRQ ₇ hold time	tIRQ1H	10	—	10	—	10	—	ns	
NMI pulse width (for recovery from software standby mode)	tNMIW	200	—	200	—	200	—	ns	
A/D trigger setup time	tTRGS	50	—	50	—	50	—	ns	See figure 18-18
A/D trigger hold time	tTRGH	10	—	10	—	10	—	ns	
Crystal oscillator settling time (reset)	tOSC1	20	—	20	—	20	—	ms	See figure 18-9
Crystal oscillator settling time (software standby)	tOSC2	10	—	10	—	10	—	ms	See figure 17-1

Note: * tRESW2 applies when the RSTOE bit in the reset control/status register (RSTCR) is set to 1. tRESW1 applies when RSTOE is cleared to 0. tRESW1 also applies at power-up.

Table 18-6 Timing Conditions of On-Chip Supporting Modules

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

$T_a = -20$ to 75°C (Regular specifications)

$T_a = -40$ to 85°C (Wide-range specifications)

Item	Symbol	6 MHz		8 MHz		10 MHz		Test	
		min	max	min	max	min	max	Unit	Conditions
FRT	Timer output delay time	tFTOD	—	100	—	100	—	100	ns
	Timer input setup time	tFTIS	50	—	50	—	50	—	ns
	Timer clock input setup time	tFTCS	50	—	50	—	50	—	ns
	Timer clock pulse width	tFTCW	1.5	—	1.5	—	1.5	—	t _{cyc}
TMR	Timer output delay time	tTMOD	—	100	—	100	—	100	ns
	Timer clock input setup time	tTMCS	50	—	50	—	50	—	ns
	Timer clock pulse width	tTMCW	1.5	—	1.5	—	1.5	—	t _{cyc}
	Timer reset input setup time	tTMRS	50	—	50	—	50	—	ns
SCI	Input clock cycle	(Async) tScyc	2	—	2	—	2	—	t _{cyc}
		(Sync)	4	—	4	—	4	—	t _{cyc}
	Input clock pulse width	tSCKW	0.4	0.6	0.4	0.6	0.4	0.6	t _{cyc}
	Transmit data delay time	(Sync) tTXD	—	100	—	100	—	100	ns
	Receive data setup time	(Sync) tRXS	100	—	100	—	100	—	ns
	Receive data hold time	(Sync) tRXH	—	100	—	100	—	100	ns
Ports	Output data delay time	tPWD	—	100	—	100	—	100	ns
	Input data setup time	tPRS	50	—	50	—	50	—	ns
	Input data hold time	tPRH	50	—	50	—	50	—	ns

• Measurement Conditions for AC Characteristics

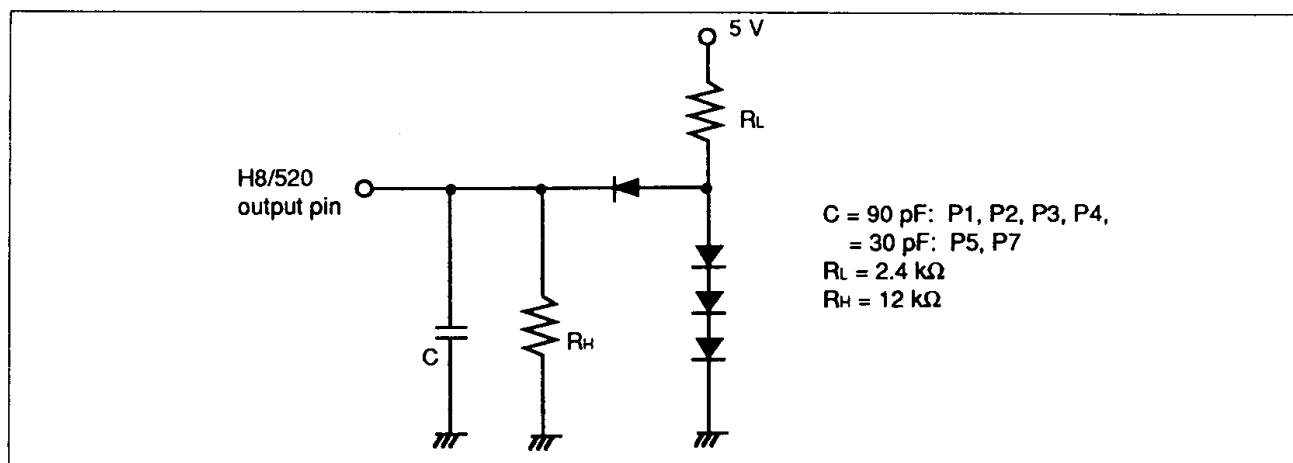


Figure 18-3 Output Load Circuit

18.2.3 A/D Converter Characteristics

Table 18-7 lists the characteristics of the on-chip A/D converter.

Table 18-7 (1) A/D Converter Characteristics

Conditions: $V_{CC} = AV_{CC} = 5.0 \text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0 \text{ V}$,
 $T_a = -40 \text{ to } 85^\circ\text{C}$ (Wide-range specifications)

Item	6 MHz			8 MHz			10 MHz			Unit
	min	typ	max	min	typ	max	min	typ	max	
Resolution	10	10	10	10	10	10	10	10	10	Bits
Conversion time	—	—	23.0	—	—	17.25	—	—	13.8	μs
Analog input capacitance	—	—	20	—	—	20	—	—	20	pF
Allowable signal-source impedance	—	—	10	—	—	10	—	—	10	k Ω
Nonlinearity error	—	—	± 2.0	—	—	± 2.0	—	—	± 2.0	LSB
Offset error	—	—	± 2.0	—	—	± 2.0	—	—	± 2.0	LSB
Full-scale error	—	—	± 2.0	—	—	± 2.0	—	—	± 2.0	LSB
Quantizing error	—	—	± 0.5	—	—	± 0.5	—	—	± 0.5	LSB
Absolute accuracy	—	—	± 2.5	—	—	± 2.5	—	—	± 2.5	LSB

Table 18-7 (2) A/D Converter Characteristics

Conditions: $V_{CC} = AV_{CC} = 5.0 \text{ V} \pm 10\%$, $V_{SS} = AV_{SS} = 0 \text{ V}$,
 $T_a = -20 \text{ to } 75^\circ\text{C}$ (Regular specifications)

Item	6 MHz			8 MHz			10 MHz			Unit
	min	typ	max	min	typ	max	min	typ	max	
Resolution	10	10	10	10	10	10	10	10	10	Bits
Conversion time	—	—	23.0	—	—	17.25	—	—	13.8	μs
Analog input capacitance	—	—	20	—	—	20	—	—	20	pF
Allowable signal-source impedance	—	—	10	—	—	10	—	—	10	k Ω
Nonlinearity error	—	—	± 3.5	—	—	± 3.5	—	—	± 3.5	LSB
Offset error	—	—	± 3.5	—	—	± 3.5	—	—	± 3.5	LSB
Full-scale error	—	—	± 3.5	—	—	± 3.5	—	—	± 3.5	LSB
Quantizing error	—	—	± 0.5	—	—	± 0.5	—	—	± 0.5	LSB
Absolute accuracy	—	—	± 4.0	—	—	± 4.0	—	—	± 4.0	LSB

18.3 MCU Operational Timing

This section provides the following timing charts:

18.3.1 Bus timing	Figures 18-4 and 18-5
18.3.2 Control Signal Timing	Figures 18-6 to 18-8
18.3.3 Clock Timing	Figure 18-9
18.3.4 I/O Port Timing	Figure 18-10
18.3.5 16-Bit Free-Running Timer Timing	Figures 18-11 and 18-12
18.3.6 8-Bit Timer Timing	Figures 18-13 to 18-15
18.3.7 SCI Timing	Figures 18-16 and 18-17

18.3.1 Bus Timing

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

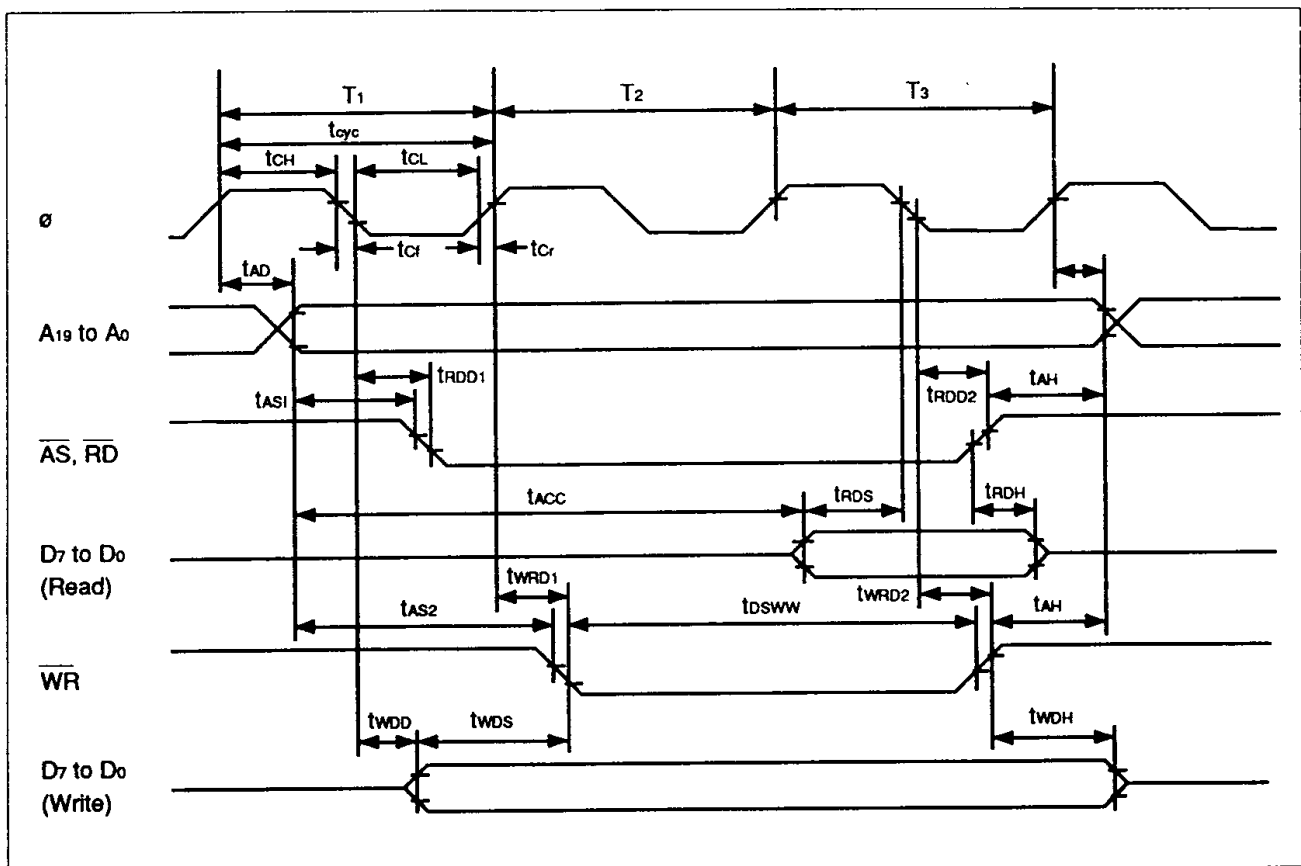


Figure 18-4 Basic Bus Cycle (without Wait States) in Expanded Modes

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

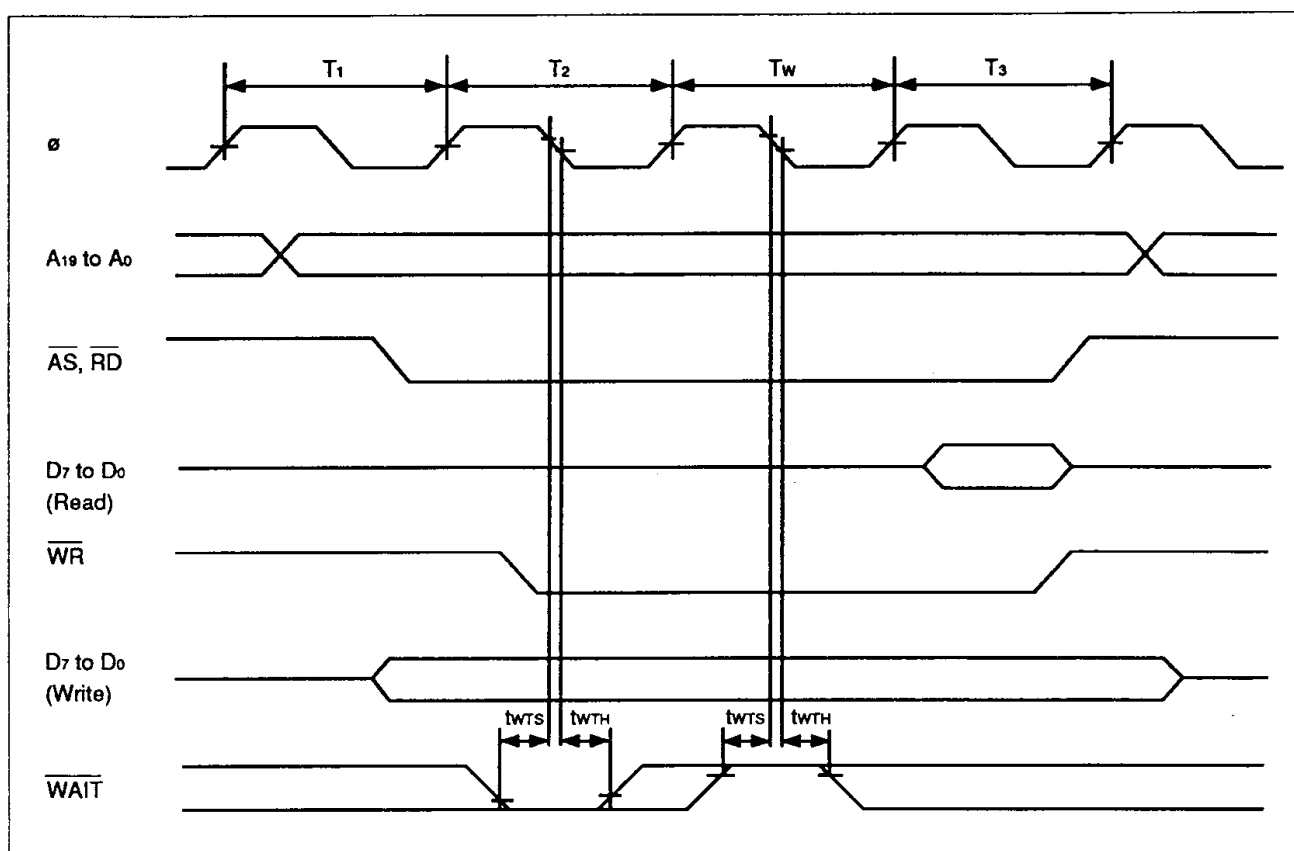


Figure 18-5 Basic Bus Cycle (with 1 Wait State) in Expanded Modes

18.3.2 Control Signal Timing

1. Reset Input Timing

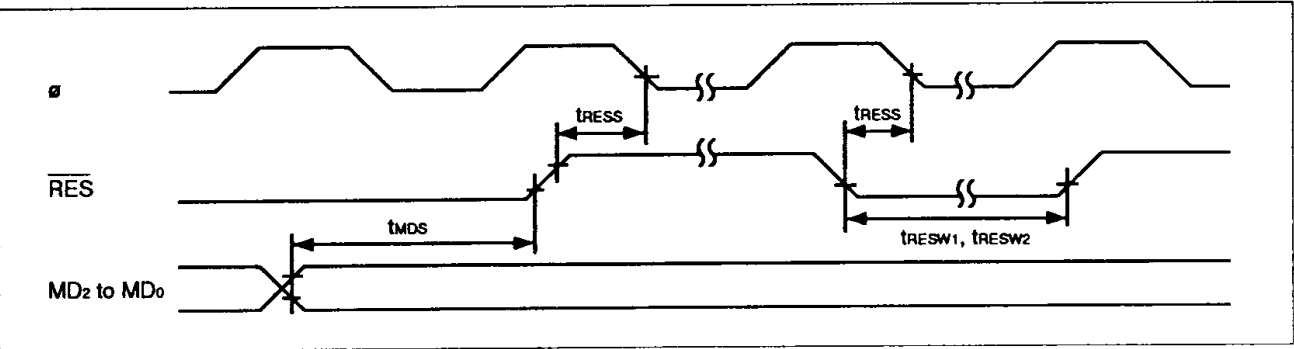


Figure 18-6 Reset Input Timing

2. Reset Output Timing

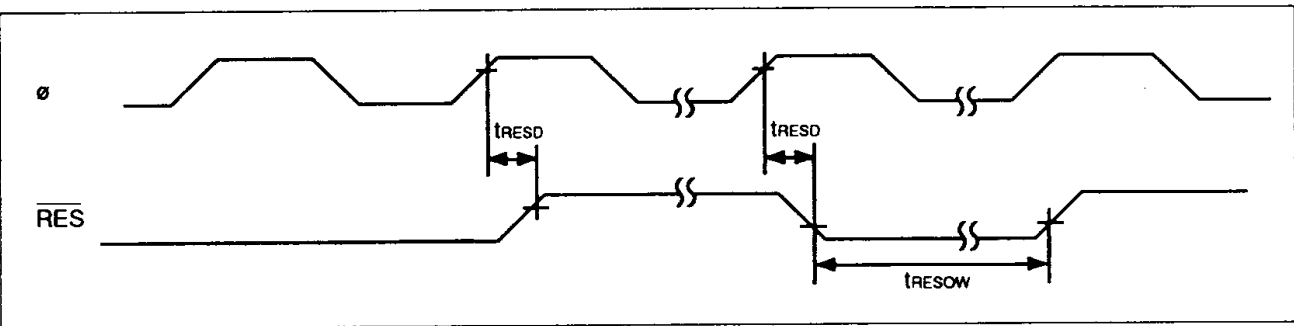


Figure 18-7 Reset Output Timing

3. Interrupt Input Timing

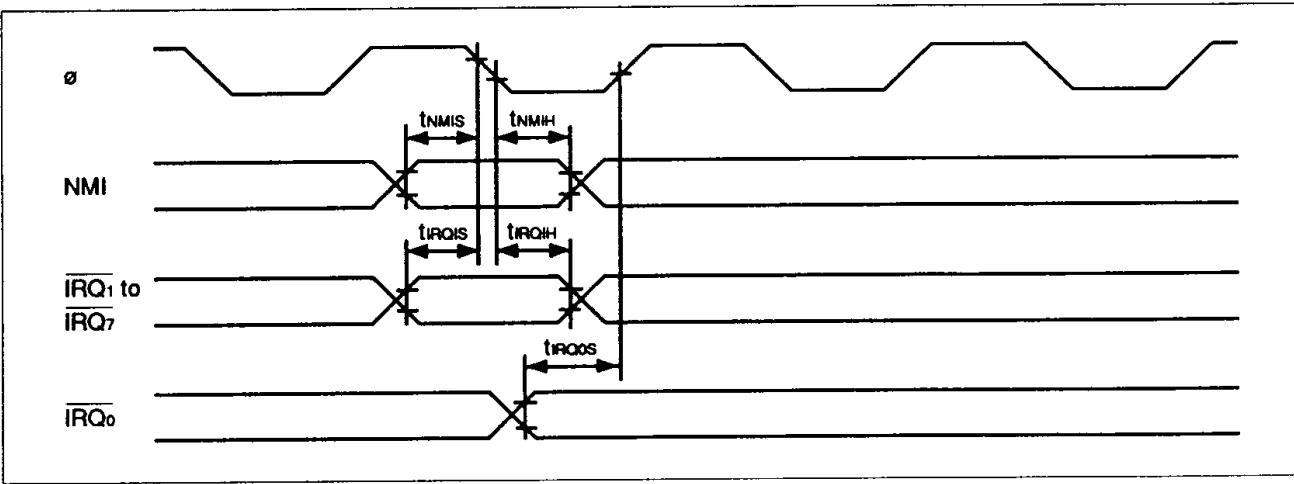


Figure 18-8 Interrupt Input Timing

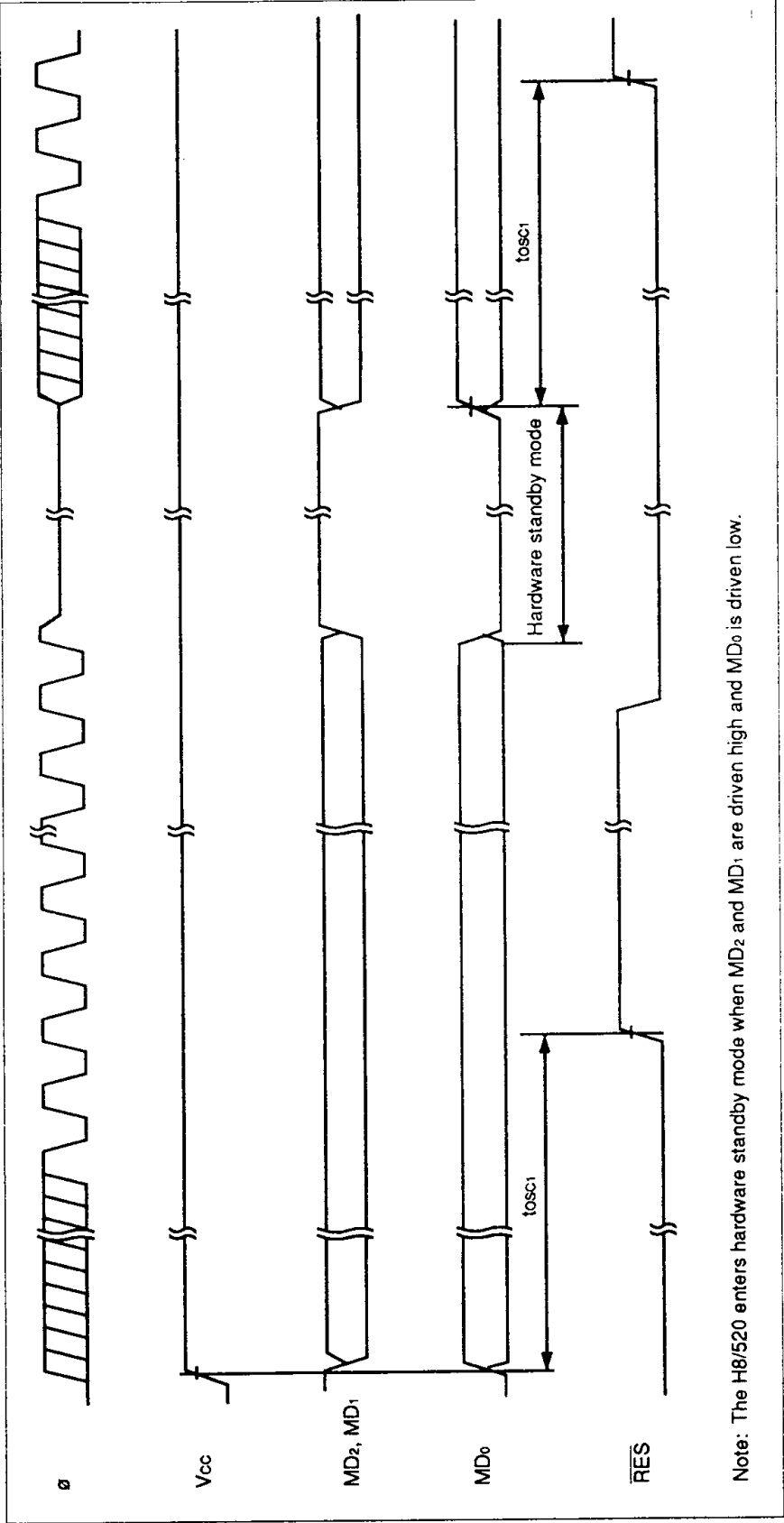


Figure 18-9 Clock Oscillator Stabilization

18.3.4 I/O Port Timing

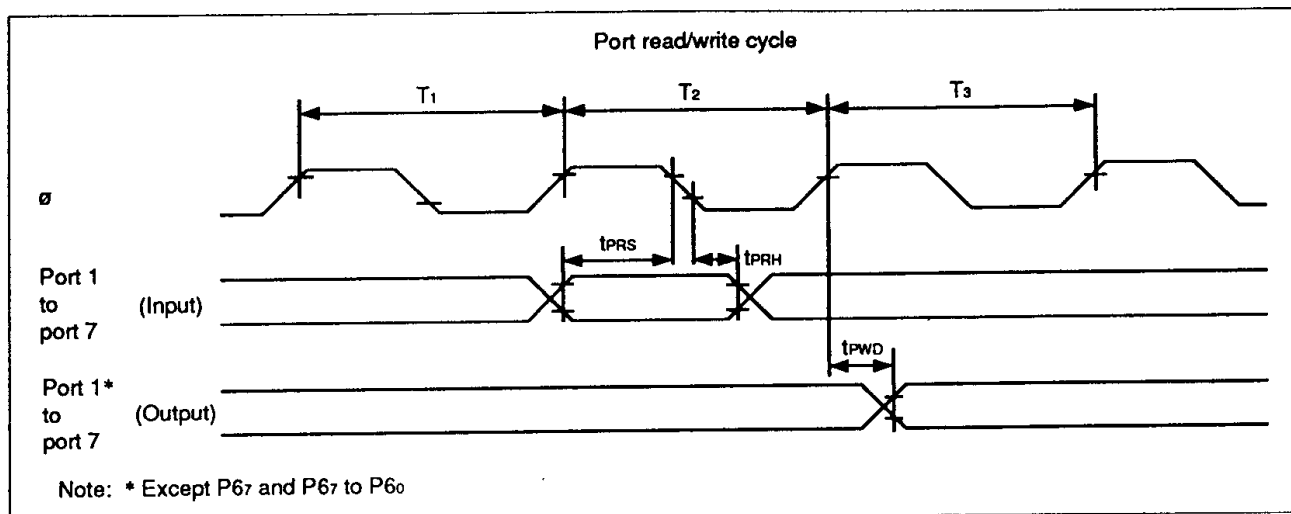


Figure 18-10 I/O Port Input/Output Timing

18.3.5 16-Bit Free-Running Timer Timing

1. Free-Running Timer Input/Output Timing

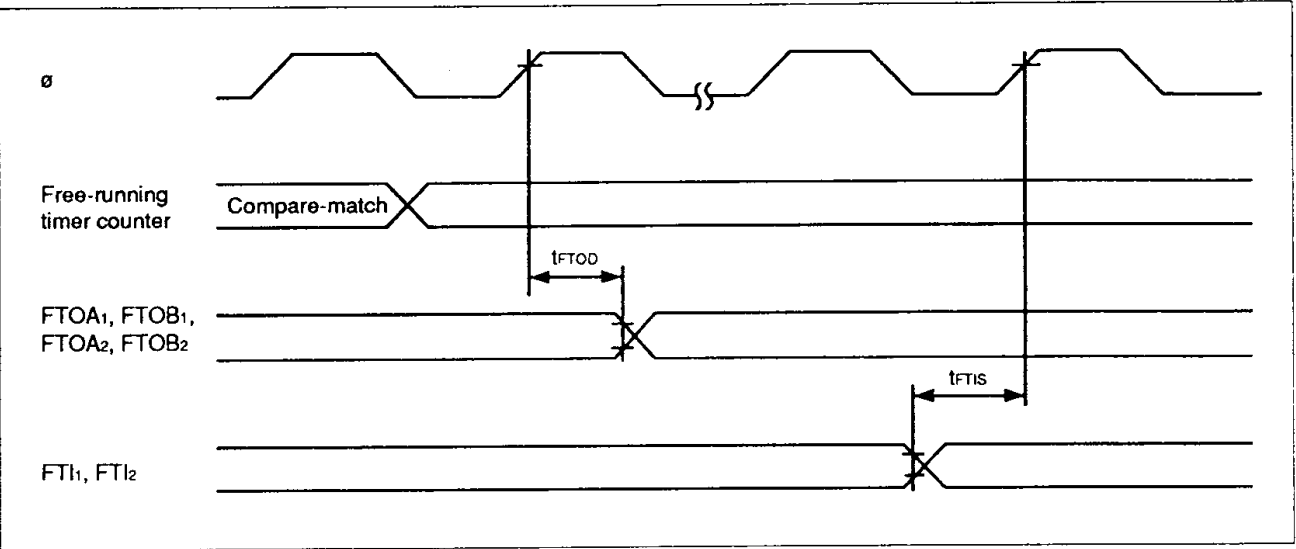


Figure 18-11 Free-Running Timer Input/Output Timing

2. External Clock Input Timing for Free-Running Timers

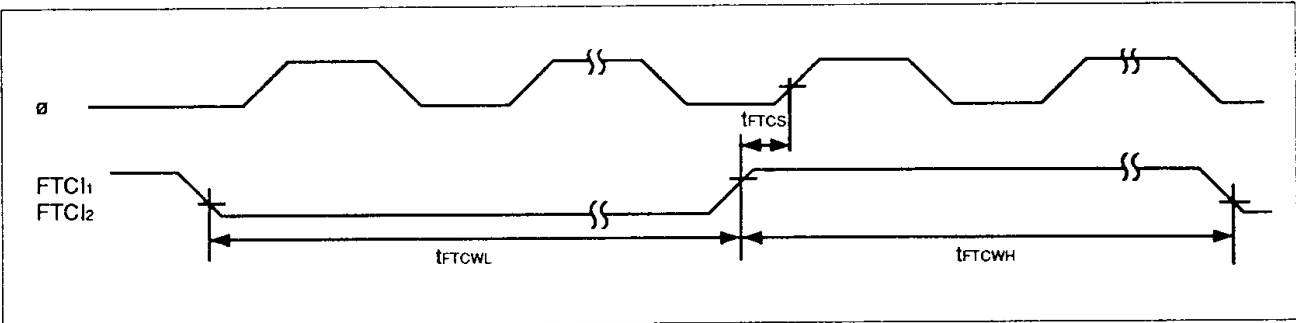


Figure 18-12 External Clock Input Timing for Free-Running Timers

18.3.6 8-Bit Timer Timing

1. 8-Bit Timer Output Timing

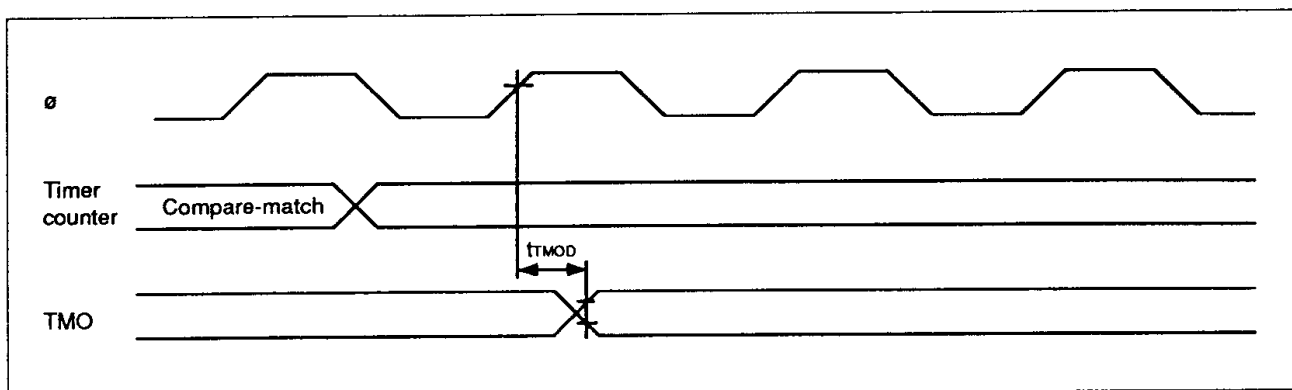


Figure 18-13 8-Bit Timer Output Timing

2. 8-Bit Timer Clock Input Timing

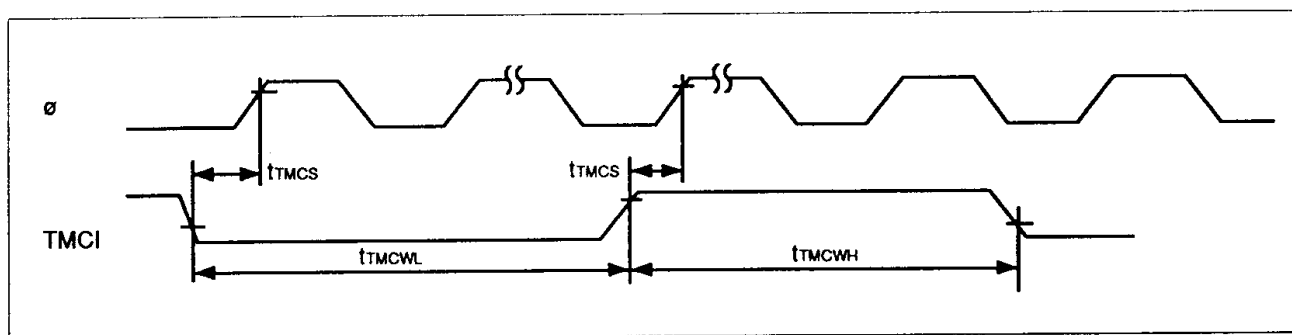


Figure 18-14 8-Bit Timer Clock Input Timing

3. 8-Bit Timer Reset Input Timing

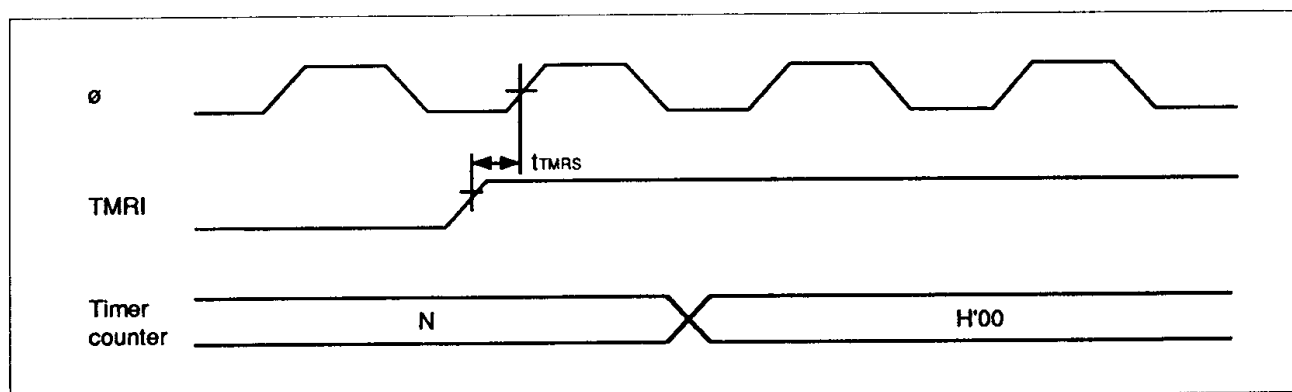


Figure 18-15 8-Bit Timer Reset Input Timing

18.3.7 Serial Communication Interface Timing

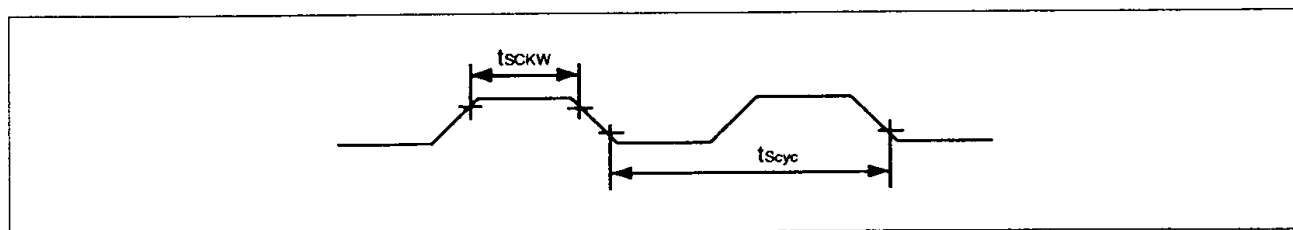


Figure 18-16 SCI Input Clock Timing

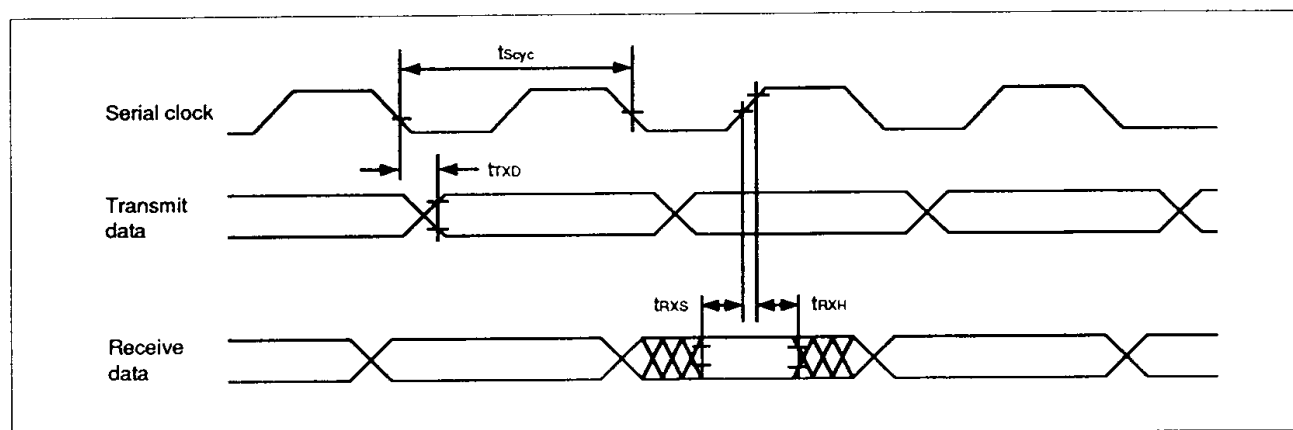


Figure 18-17 SCI Input/Output Timing (Synchronous Mode)

18.3.8 A/D External Trigger Input Timing

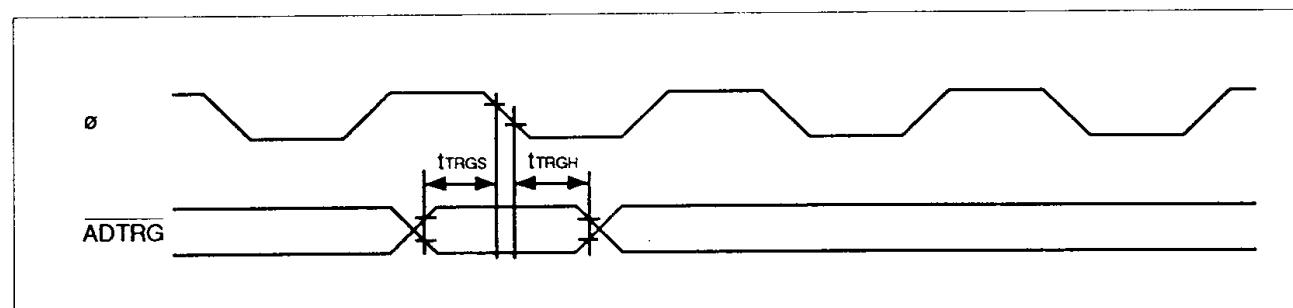


Figure 18-18 A/D External Trigger Input Timing

T-90-20

Appendix F Package Dimensions

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

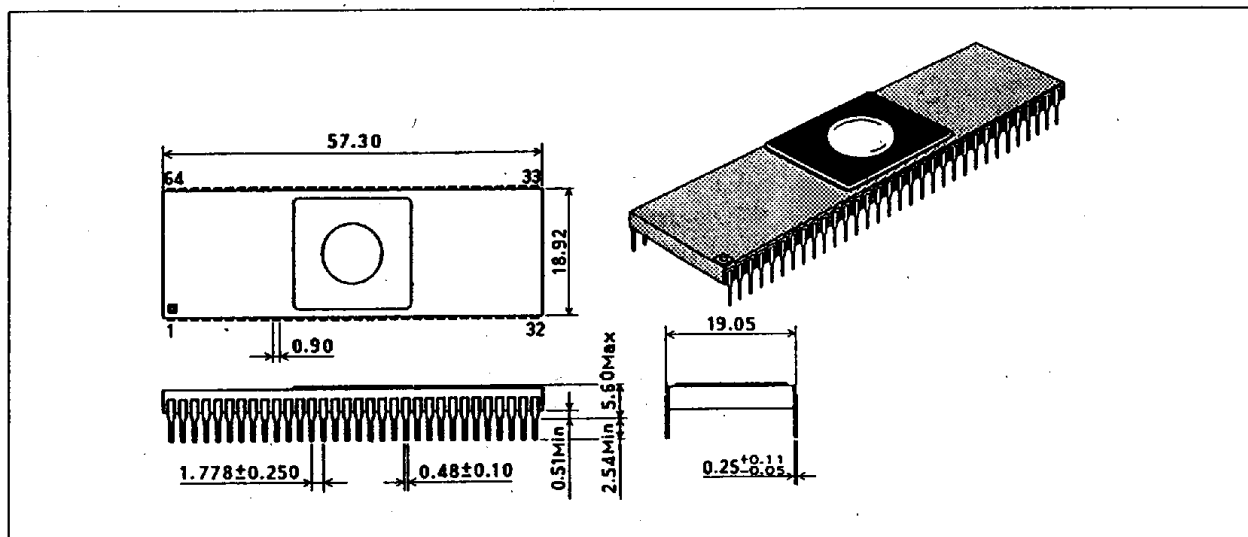


Figure F-1 Package Dimensions (DC-64S)

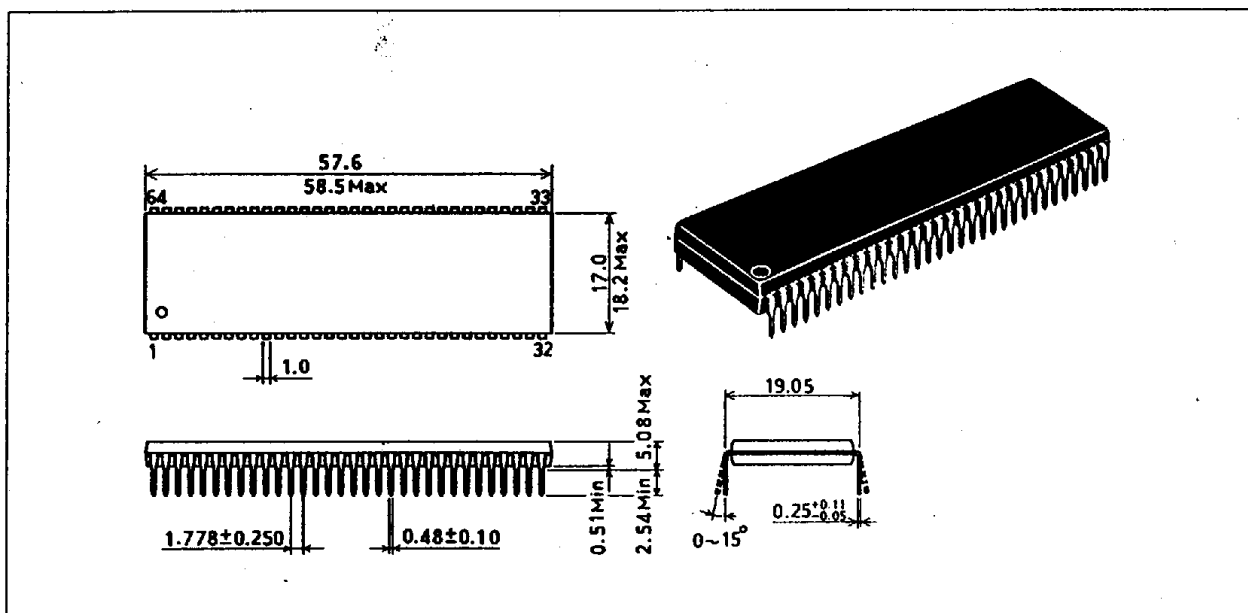


Figure F-2 Package Dimensions (DP-64S)

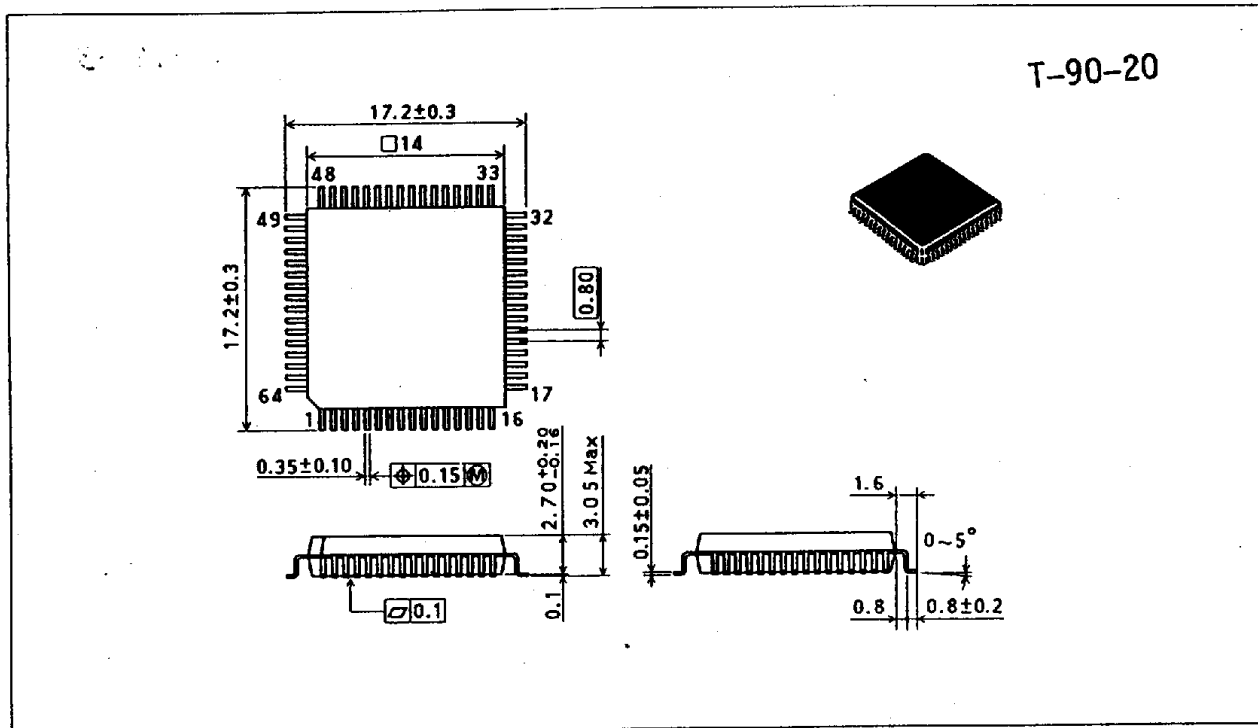


Figure F-3 Package Dimensions (FP-64A)

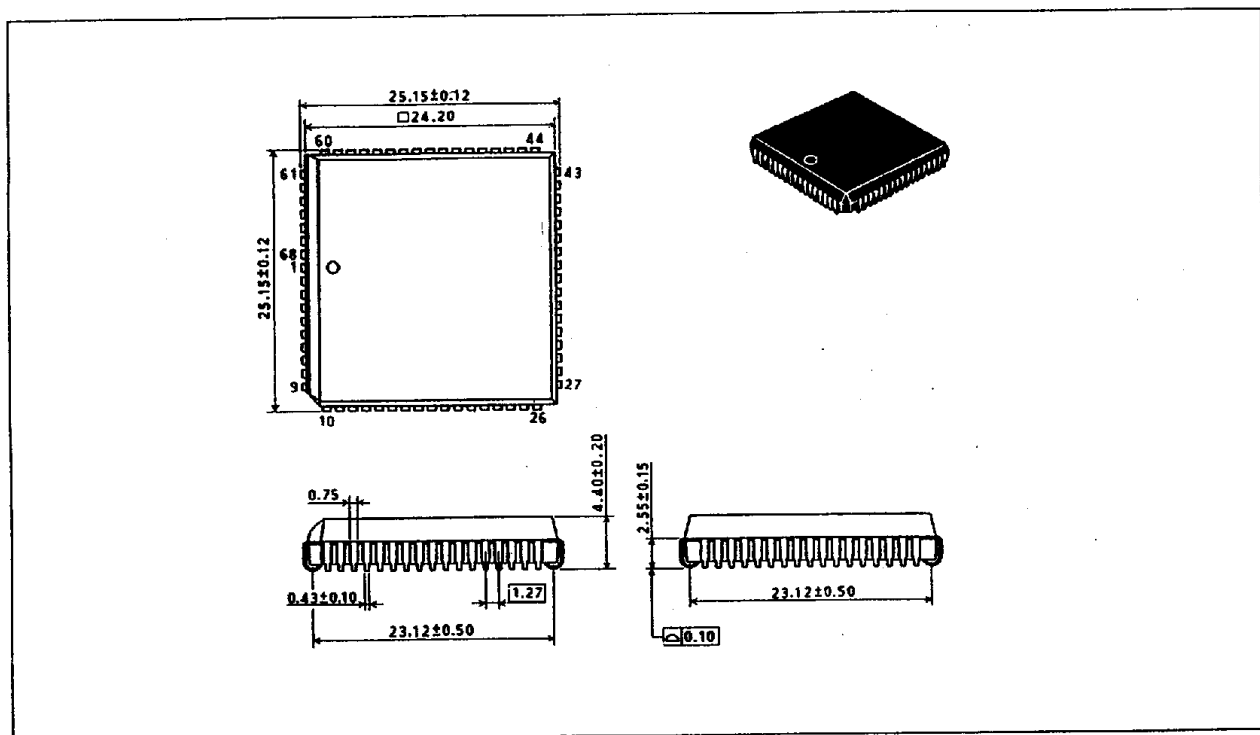


Figure F-4 Package Dimensions (CP-68)