Section 20 Electrical Specifications

20.1 Absolute Maximum Ratings

Table 20-1 lists the absolute maximum ratings.

Table 20-1 Absolute Maximum Ratings

Item		Symbol	Rating	Unit
Supply voltage		V_{CC}	–0.3 to +7.0	V
Programming voltage		V_{PP}	–0.3 to +13.5	V
Input voltage	(except port 8)	V_{in}	–0.3 to V_{CC} + 0.3	V
	(port 8)	V_{in}	–0.3 to AV_{CC} + 0.3	V
Analog supply voltage		AV_{CC}	–0.3 to +7.0	V
Analog input voltage		V_{AN}	–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 LSI damage may occur if maximum ratings are exceeded. Normal operation should be under recommended operating conditions.

20.2 Electrical Characteristics

20.2.1 DC Characteristics

Table 20-2 lists the DC characteristics.

Table 20-2 DC Characteristics

Conditions: V_{CC} = 5.0V ±10%*1, AV_{CC} = 5.0V ±10%,*1 V_{SS} = AV_{SS} = 0V,
T_a = –20 to +75°C (Regular Specifications)
T_a = –40 to +85°C (Wide-Range Specifications)

Item		Symbol	Min	Typ	Max	Unit	Measurement Conditions
Input High voltage	$\overline{RES}$, $\overline{STBY}$, MD_2, MD_1, MD_0	V_{IH}	V_{CC} – 0.7	–	V_{CC}+0.3	V	
	EXTAL		V_{CC} × 0.7	–	V_{CC}+0.3	V	
	Port 8		2.2	–	AV_{CC}+0.3	V	
	Other input pins (except port 7)		2.2	–	V_{CC}+0.3	V	
Input Low voltage	$\overline{RES}$, $\overline{STBY}$, MD_2, MD_1, MD_0	V_{IL}	–0.3	–	0.5	V	
	Other input pins (except port 7)		–0.3	–	0.8	V	
Schmitt trigger input voltage	Port 7	V_{T^-}	1.0	–	2.5	V	
		V_{T^+}	2.0	–	3.5	V	
		V_{T^+}–V_{T^-}	0.4	–	–	V	
Input leakage current	$\overline{RES}$	| I_{in} |	–	–	10.0	µA	V_{in} = 0.5 to V_{CC}–0.5V
	$\overline{STBY}$, NMI, MD_2, MD_1, MD_0		–	–	1.0	µA	
	port 8		–	–	1.0	µA	V_{in} = 0.5 to AV_{CC}–0.5V
Leakage current in 3-state (off state)	Port 9, ports 7 to 1	| I_{TSI} |	–	–	1.0	µA	V_{in} = 0.5 to V_{CC}–0.5V
Input pull-up MOS current	Ports 6 and 5	$-I_P$	50	–	200	µA	V_{in} = 0V
Output High Voltage	All output pins	V_{OH}	V_{CC}–0.5	–	–	V	I_{OH} = –200µA
			3.5	–	–	V	I_{OH} = –1mA
Output Low Voltage	All output pins	V_{OL}	–	–	0.4	V	I_{OL} = 1.6mA
	Port 4		–	–	1.0	V	I_{OL} = 8mA
			–	–	1.2	V	I_{OL} = 10mA
Input capacitance	$\overline{RES}$	C_{in}	–	–	60	pF	V_{in} = 0 V
	NMI		–	–	30	pF	f = 1MHz
	All input pins except $\overline{RES}$, NMI		–	–	15	pF	T_a = 25°C

Note: *1 AVcc must be connected to a power supply line, even when the A/D converter is not used.

Table 20-2 DC Characteristics (cont)

Item		Sym-bol	Min	Typ	Max	Unit	Measurement Conditions
Current dissipation*2	Normal operation	I_{CC}	–	20	30	mA	f = 6MHz
			–	25	40	mA	f = 8MHz
			–	30	50	mA	f = 10MHz
	Sleep mode		–	12	20	mA	f = 6MHz
			–	16	25	mA	f = 8MHz
			–	20	30	mA	f = 10MHz
	Standby		–	0.01	5.0	µA	Ta ≤ 50°C
			–	–	20	µA	Ta > 50°C
Analog supply current	During A/D conversion	AI_{CC}	–	1.2	2.0	mA	
	While waiting		–	0.01	5.0	µA	
RAM standby voltage		V_{RAM}	2.0	–	–	V	

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

Table 20-3 Allowable Output Current Sink Values

Conditions: V_{CC} = 5.0V ±10%, AV_{CC} = 5.0V ±10%, V_{SS} = AV_{SS} = 0V,
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 4	I_{OL}	–	–	10	mA
	Other output pins		–	–	2.0	mA
Allowable output Low current sink (total)	Port 4, total of 8 pins	ΣI_{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	$\Sigma -I_{OH}$	–	–	25	mA

Note: To avoid degrading the reliability of the chip, be careful not to exceed the output current sink values in table 20-3. 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 20-1 and 20-2.

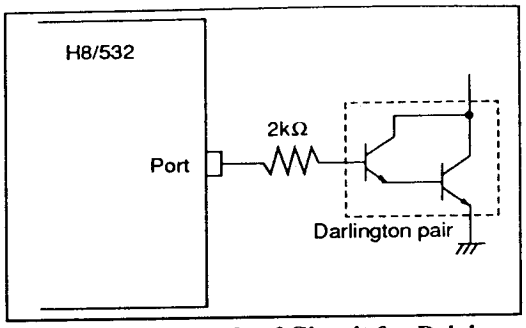

Figure 20-1 Example of Circuit for Driving a Darlington Transistor Pair

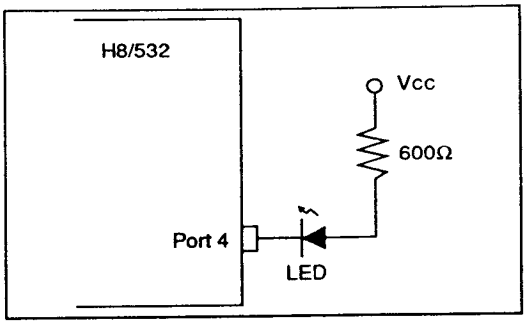

Figure 20-2 Example of Circuit for Driving an LED

20.2.2 AC Characteristics

The AC characteristics of the H8/532 chip are listed in three tables. Bus timing parameters are given in table 20-4, control signal timing parameters in table 20-5, and timing parameters of the on-chip supporting modules in table 20-6.

Table 20-4 Bus Timing

Conditions: V_{CC} = 5.0V ±10%, AV_{CC} = 5.0V ±10%, ø = 0.5 to 10MHz, V_{SS} = 0V
T_a = –20 to +75°C (Regular Specifications)
T_a = –40 to +85°C (Wide-Range Specifications)

		6MHz		8MHz		10MHz			Measurement
Item	Symbol	Min	Max	Min	Max	Min	Max	Unit	Conditions
Clock cycle time	t_{cyc}	166.7	2000	125	2000	100	2000	ns	See figure 20-4
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	–	65	–	65	ns	
Address hold time	t_{AH}	30	–	25	–	20	–	ns	
Data strobe delay time 1	t_{DSD1}	–	70	–	60	–	40	ns	
Data strobe delay time 2	t_{DSD2}	–	70	–	60	–	50	ns	
Data strobe delay time 3	t_{DSD3}	–	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	

Table 20-4 Bus Timing (cont)

Item	Symbol	6MHz Min	6MHz Max	8MHz Min	8MHz Max	10MHz Min	10MHz Max	Unit	Measurement Conditions
Address setup time 2	t_{AS2}	105	–	80	–	65	–	ns	See figure 20-4
Read data setup time	t_{RDS}	60	–	50	–	40	–	ns	
Read data hold time	t_{RDH}	0	–	0	–	0	–	ns	
Read data access time	t_{ACC}	–	280	–	190	–	160	ns	
Write data delay time	t_{WDD}	–	70	–	65	–	65	ns	
Write data setup time	t_{WDS}	30	–	15	–	10	–	ns	
Write data hold time	t_{WDH}	30	–	25	–	20	–	ns	
Wait setup time	t_{WTS}	40	–	40	–	40	–	ns	See figure 20-5
Wait hold time	t_{WTH}	10	–	10	–	10	–	ns	
Bus request setup time	t_{BRQS}	40	–	40	–	40	–	ns	See figure 20-10
Bus acknowledge delay time 1	t_{BACD1}	–	70	–	60	–	55	ns	
Bus acknowledge delay time 2	t_{BACD2}	–	70	–	60	–	55	ns	
Bus floating delay time	t_{BZD}	–	t_{BACD1}	–	t_{BACD1}	–	t_{BACD1}	ns	
E clock delay time	t_{ED}	–	20	–	15	–	15	ns	See figure 20-11
E clock rise time	t_{Er}	–	15	–	15	–	15	ns	
E clock fall time	t_{Ef}	–	15	–	15	–	15	ns	
Read data hold time (E clock sync)	t_{RDHE}	0	–	0	–	0	–	ns	See figure 20-6
Write data hold time (E clock sync)	t_{WDHE}	50	–	40	–	30	–	ns	

Table 20-5 Control Signal Timing

Conditions: V_{CC} = 5.0V ±10%, AV_{CC} = 5.0V ±10%, ø = 0.5 to 10MHz, V_{SS} = 0V
T_a = –20 to +75°C (Regular Specifications)
T_a = –40 to +85°C (Wide-Range Specifications)

Item	Symbol	6MHz Min	6MHz Max	8MHz Min	8MHz Max	10MHz Min	10MHz Max	Unit	Measurement Conditions
$\overline{RES}$ setup time	t_{RESS}	200	–	200	–	200	–	ns	See figure 20-7
$\overline{RES}$ pulse width	t_{RESW}	6.0	–	6.0	–	6.0	–	t_{cyc}	
Mode programming setup time	t_{MDS}	4.0	–	4.0	–	4.0	–	t_{cyc}	
NMI setup time	t_{NMIS}	150	–	150	–	150	–	ns	See figure 20-8
NMI hold time	t_{NMIH}	10	–	10	–	10	–	ns	
$\overline{IRQ_0}$ setup time	t_{IRQ0S}	50	–	50	–	50	–	ns	
$\overline{IRQ_1}$ setup time	t_{IRQ1S}	50	–	50	–	50	–	ns	
$\overline{IRQ_1}$ hold time	t_{IRQ1H}	10	–	10	–	10	–	ns	
NMI pulse width (for recovery from software standby mode)	t_{NMIW}	200	–	200	–	200	–	ns	See figure 20-9
Crystal oscillator settling time (reset)	t_{OSC1}	20	–	20	–	20	–	ms	See figure 20-12
Crystal oscillator settling time (software standby)	t_{OSC2}	10	–	10	–	10	–	ms	See figure 18-1

Table 20-6 Timing Conditions of On-Chip Supporting Modules

Conditions: V_{CC} = 5.0V ±10%, AV_{CC} = 5.0V ±10%, ø = 0.5 to 10MHz, V_{SS} = 0V
T_a = –20 to +75°C (Regular Specifications)
T_a = –40 to +85°C (Wide-Range Specifications)

Item			Symbol	6MHz Min	6MHz Max	8MHz Min	8MHz Max	10MHz Min	10MHz Max	Unit	Measurement Conditions
FRT	Timer output delay time		t_{FTOD}	–	100	–	100	–	100	ns	See figure 20-14
	Timer input setup time		t_{FTIS}	50	–	50	–	50	–	ns	
	Timer clock input setup time		t_{FTCS}	50	–	50	–	50	–	ns	See figure 20-15
	Timer clock pulse width		t_{FTCWL}, t_{FTCWH}	1.5	–	1.5	–	1.5	–	t_{cyc}	
TMR	Timer output delay time		t_{TMOD}	–	100	–	100	–	100	ns	See figure 20-16
	Timer clock input setup time		t_{TMCS}	50	–	50	–	50	–	ns	See figure 20-17
	Timer clock pulse width		t_{TMCWL}, t_{TMCWH}	1.5	–	1.5	–	1.5	–	t_{cyc}	
	Timer reset input setup time		t_{TMRS}	50	–	50	–	50	–	ns	See figure 20-18
PWM	Timer output delay time		t_{PWOD}	–	100	–	100	–	100	ns	See figure 20-19
SCI	Input clock cycle	(Async)	t_{Scyc}	2	–	2	–	2	–	t_{cyc}	See figure 20-20
		(Sync)		4	–	4	–	4	–	t_{cyc}	
	Input clock pulse width		t_{SCKW}	0.4	0.6	0.4	0.6	0.4	0.6	t_{Scyc}	
	Transmit data delay time	(Sync)	t_{TXD}	–	100	–	100	–	100	ns	See figure 20-21
	Receive data setup time	(Sync)	t_{RXS}	100	–	100	–	100	–	ns	
	Receive data hold time	(Sync)	t_{RXH}	100	–	100	–	100	–	ns	
Port	Output data delay time		t_{PWD}	–	100	–	100	–	100	ns	See figure 20-13
	Input data setup time		t_{PRS}	50	–	50	–	50	–	ns	
	Input data hold time		t_{PRH}	50	–	50	–	50	–	ns	

- **Measurement Conditions for AC Characteristics**

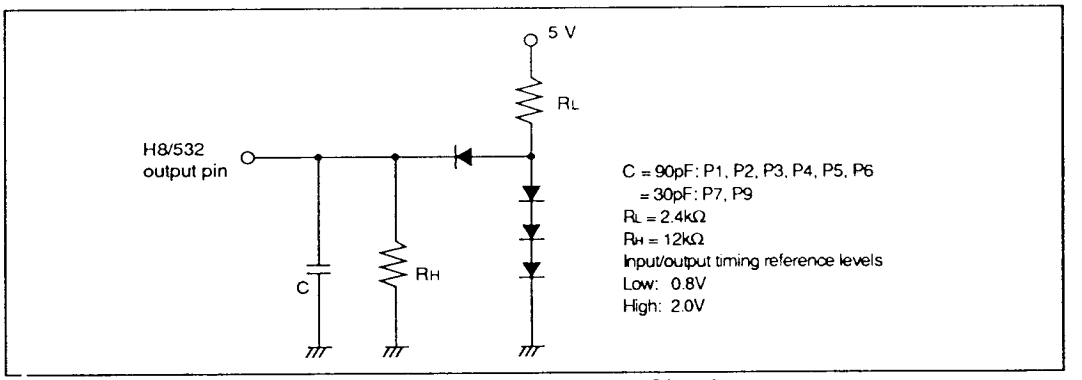

Figure 20-3 Output Load Circuit

20.2.3 A/D Converter Characteristics

Table 20-7 lists the characteristics of the on-chip A/D converter.

Table 20-7 A/D Converter Characteristics

Conditions: V_{CC} = 5.0V ±10%, AV_{CC} = 5.0V ±10%, V_{SS} = AV_{SS} = 0V,
T_a = –20 to +75°C (Regular Specifications)
T_a = –40 to +85°C (Wide-Range Specifications)

	6MHz			8MHz			10MHz			
Item	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
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	kΩ
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

20.3 MCU Operational Timing

This section provides the following timing charts:

20.3.1 Bus timing	Figures 20-4 to 20-6
20.3.2 Control Signal Timing	Figures 20-7 to 20-10
20.3.3 Clock Timing	Figures 20-11 and 20-12
20.3.4 I/O Port Timing	Figure 20-13
20.3.5 16-Bit Free-Running Timer Timing	Figures 20-14 and 20-15
20.3.6 8-Bit Timer Timing	Figures 20-16 to 20-18
20.3.7 Pulse Width Modulation Timer Timing	Figure 20-19
20.3.8 Serial Communication InterfaceTiming	Figure 20-20 and 20-21

20.3.1 Bus Timing

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

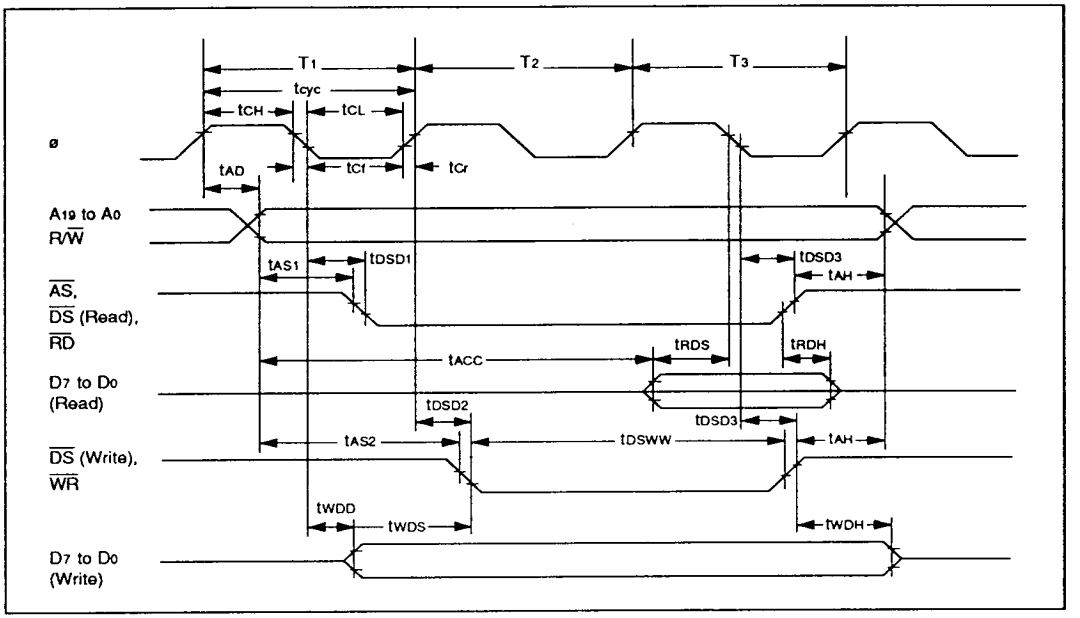

Figure 20-4 Basic Bus Cycle (without Wait States) in Expanded Modes

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

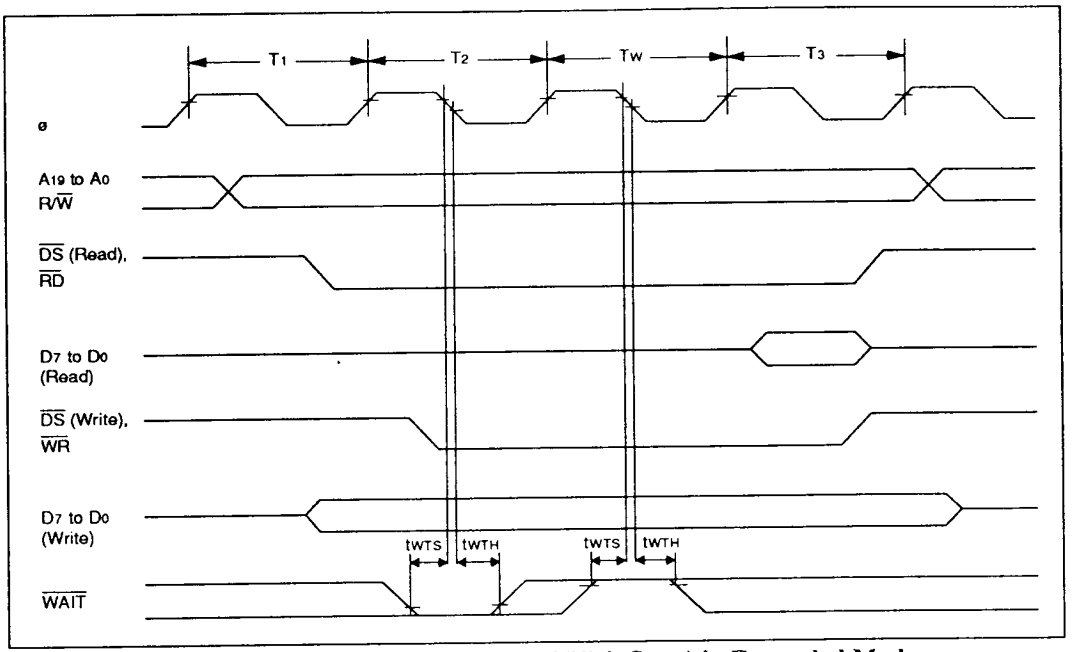

Figure 20-5 Basic Bus Cycle (with 1 Wait State) in Expanded Modes

3. Bus Cycle Synchronized with E Clock

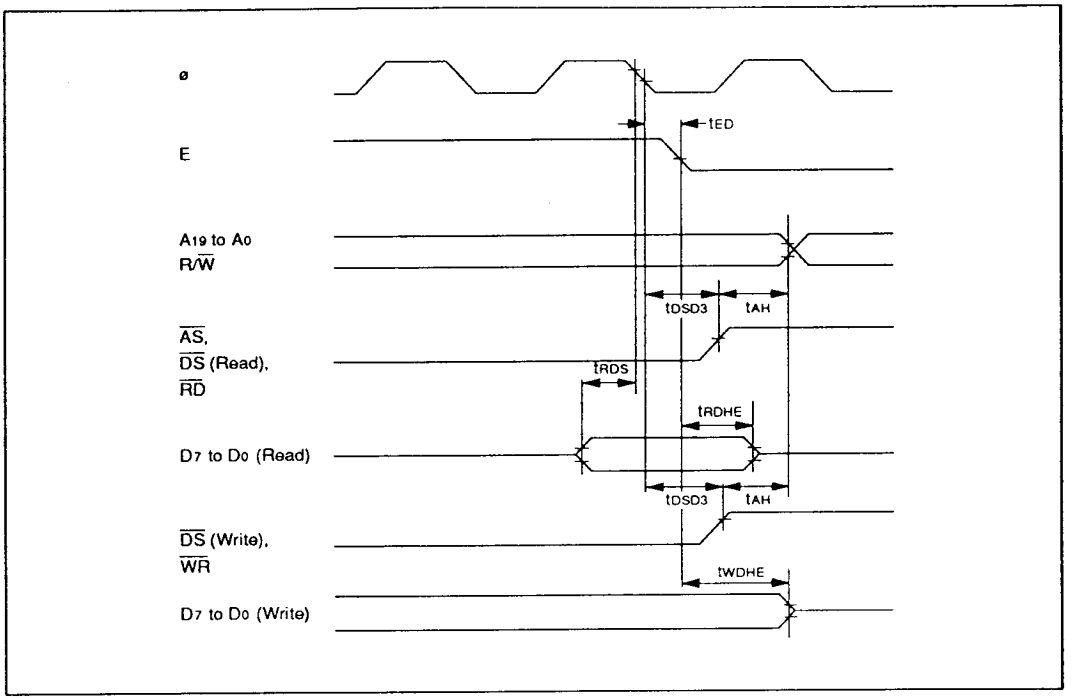

Figure 20-6 Bus Cycle Synchronized with E Clock

20.3.2 Control Signal Timing

1. Reset Input Timing

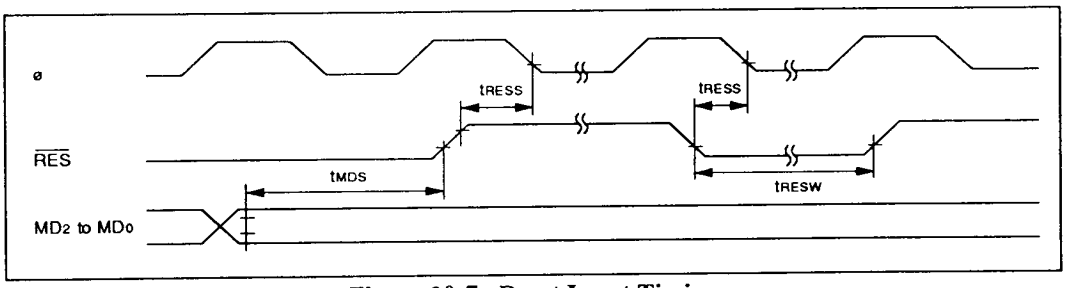

Figure 20-7 Reset Input Timing

2. Interrupt Input Timing

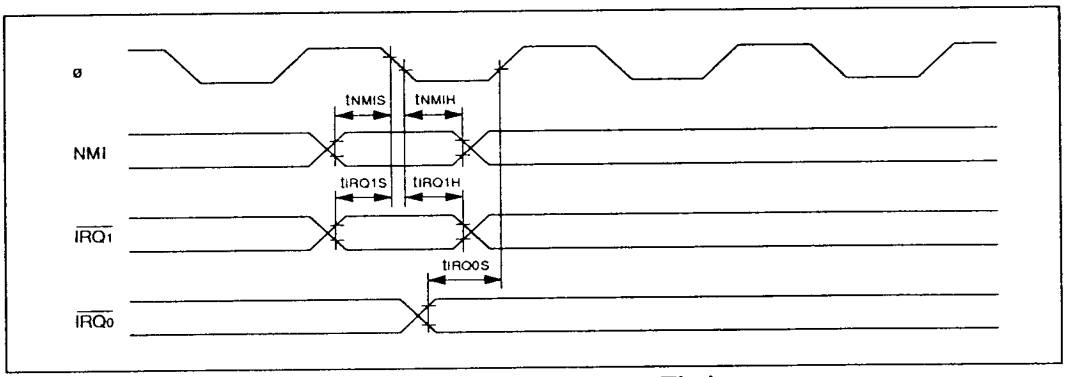

Figure 20-8 Interrupt Input Timing

3. NMI Pulse Width

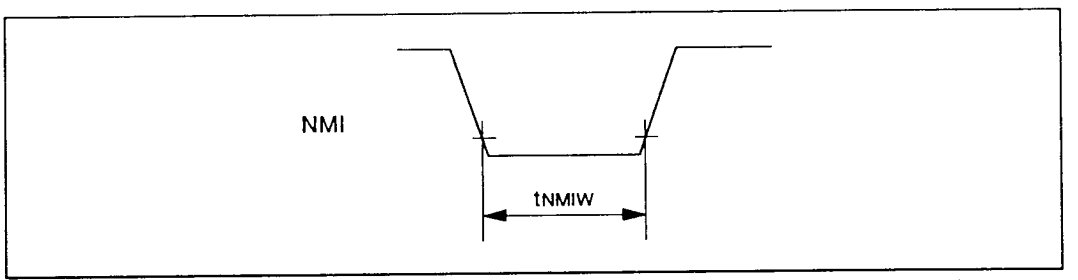

Figure 20-9 NMI Pulse Width (for Recovery from Software Standby Mode)

4. Bus Release State Timing

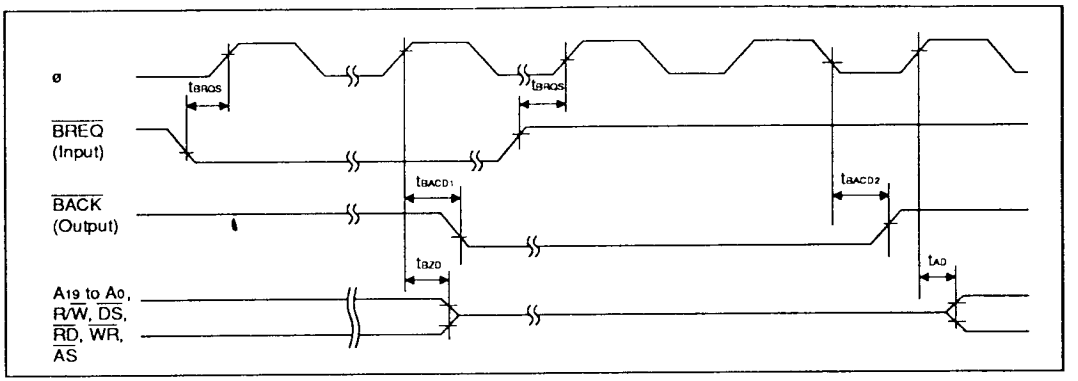

Figure 20-10 Bus Release State Timing

20.3.3 Clock Timing

1. E Clock Timing

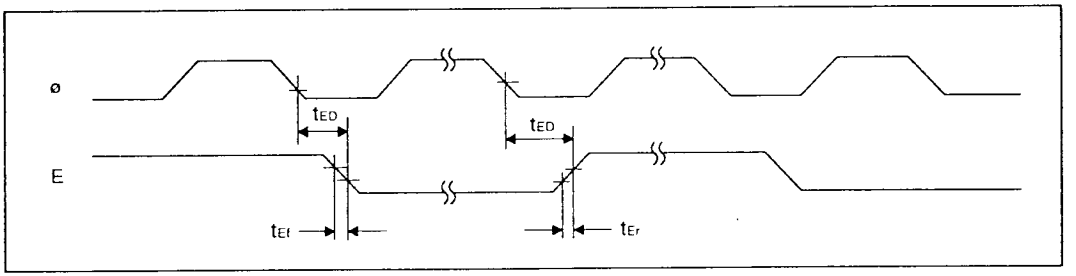

Figure 20-11 E Clock Timing

2. Clock Oscillator Stabilization Timing

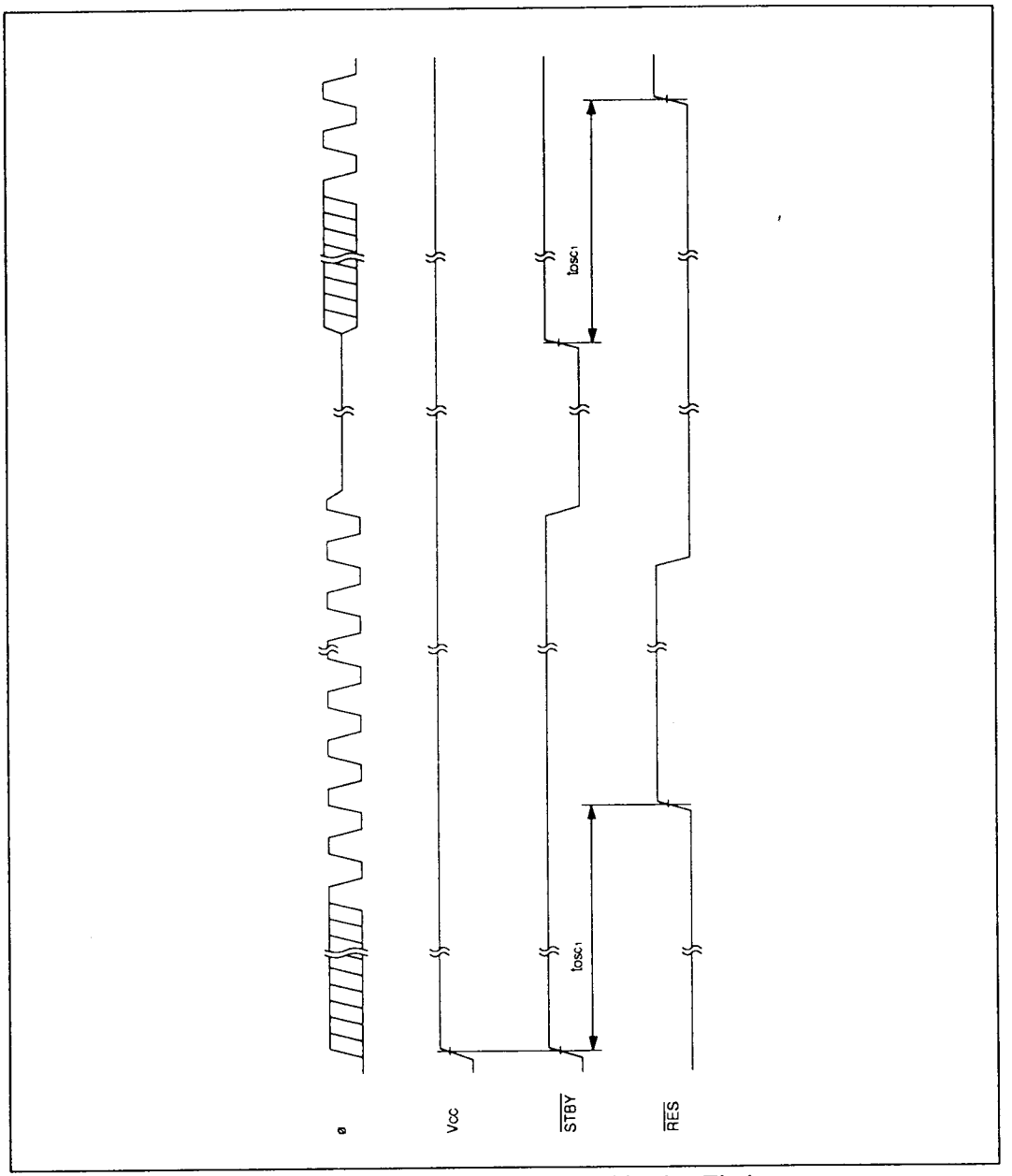

Figure 20-12 Clock Oscillator Stabilization Timing

20.3.4 I/O Port Timing

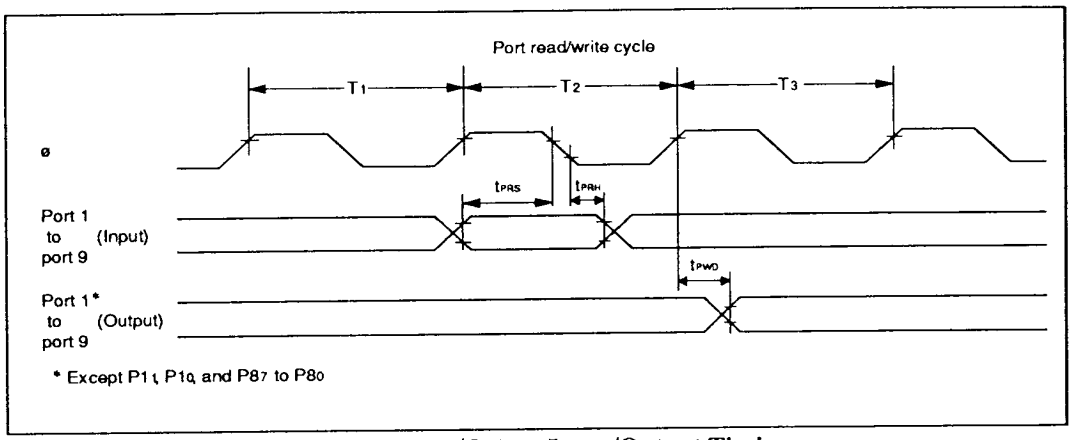

Figure 20-13 I/O Port Input/Output Timing

20.3.5 16-Bit Free-Running Timer Timing

1. Free-Running Timer Input/Output Timing

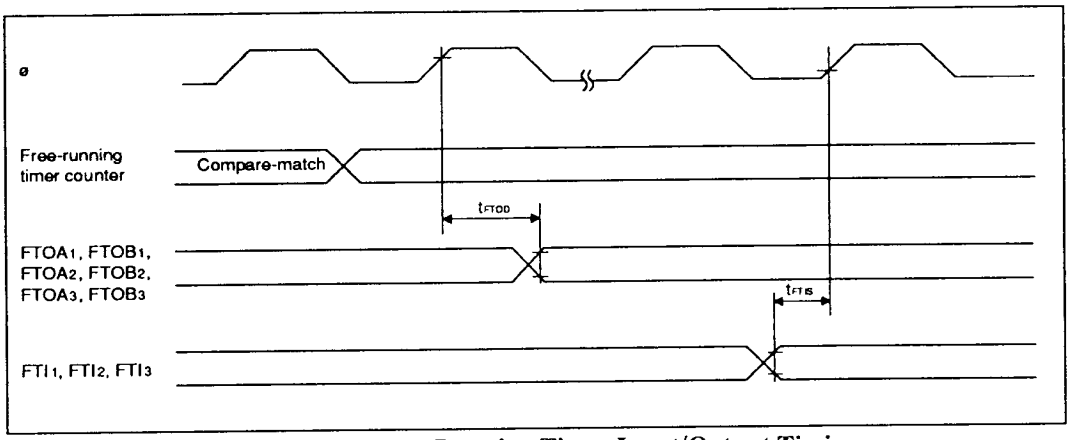

Figure 20-14 Free-Running Timer Input/Output Timing

2. External Clock Input Timing for Free-Running Timers

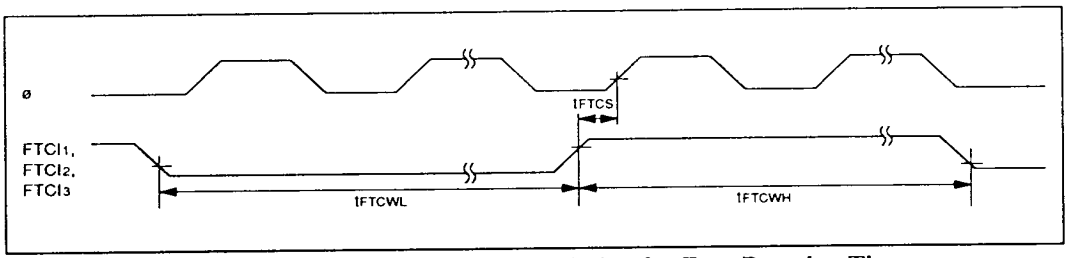

Figure 20-15 External Clock Input Timing for Free-Running Timers

20.3.6 8-Bit Timer Timing

1. 8-Bit Timer Output Timing

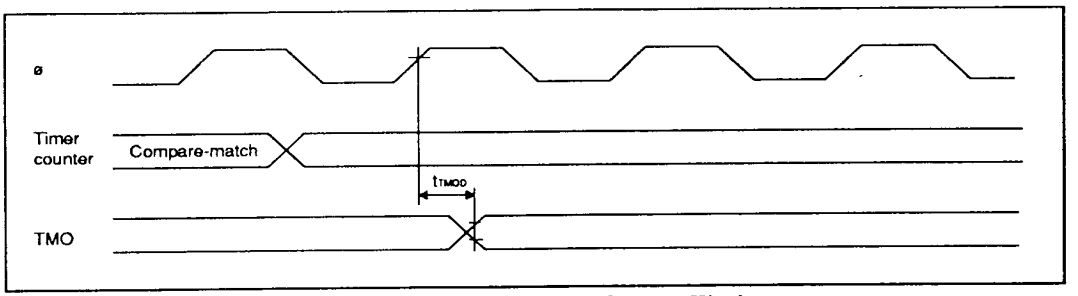

Figure 20-16 8-Bit Timer Output Timing

2. 8-Bit Timer Clock Input Timing

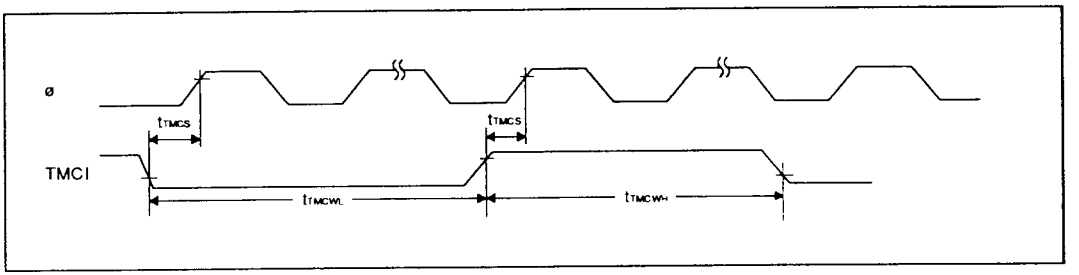

Figure 20-17 8-Bit Timer Clock Input Timing

3. 8-Bit Timer Reset Input Timing

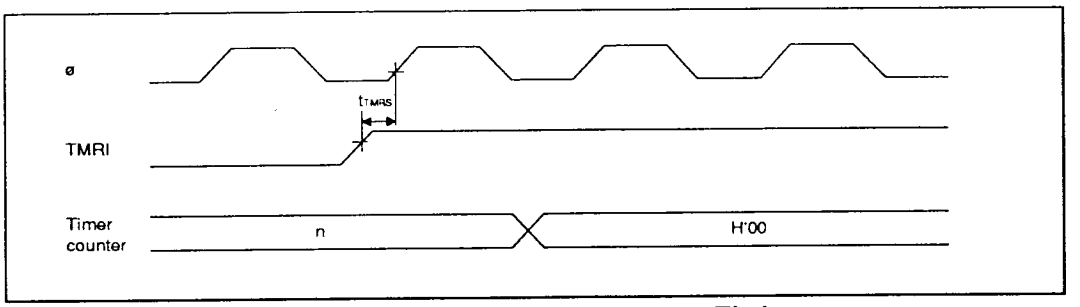

Figure 20-18 8-Bit Timer Reset Input Timing

20.3.7 Pulse Width Modulation Timer Timing

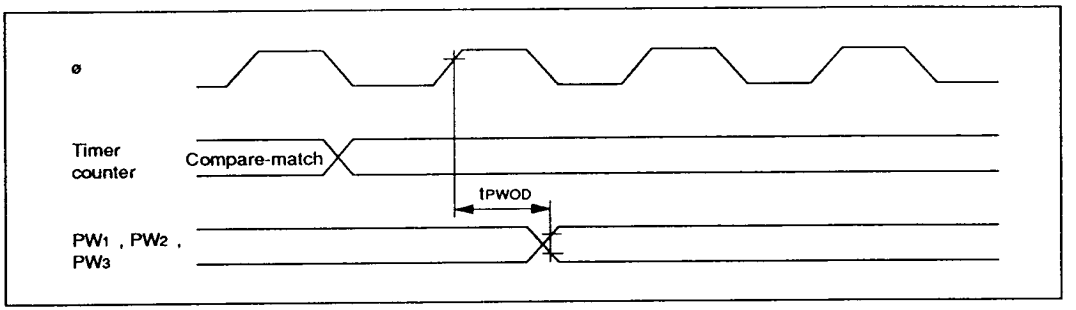

Figure 20-19 PWM Timer Output Timing

20.3.8 Serial Communication Interface Timing

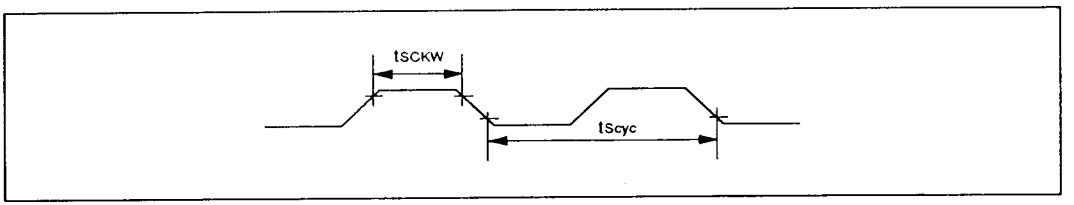

Figure 20-20 SCI Input Clock Timing

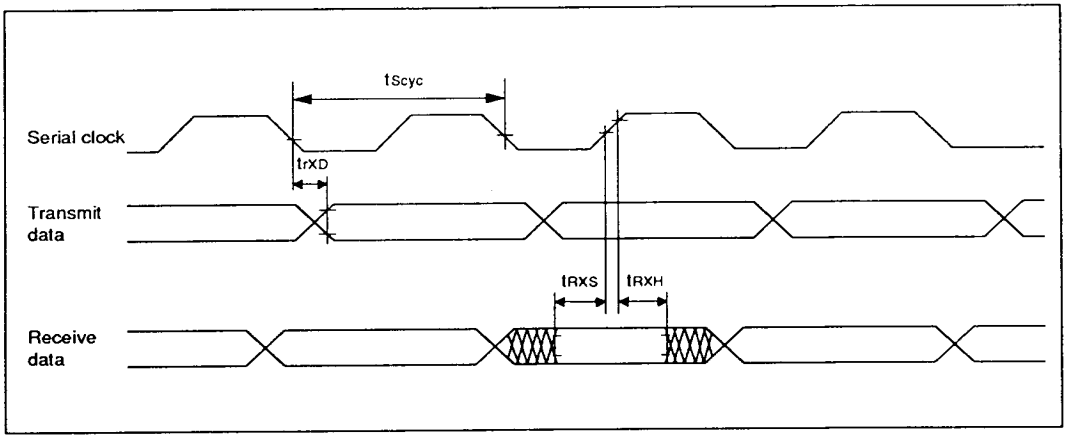

Figure 20-21 SCI Input/Output Timing (Synchronous Mode)