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.

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Table 20-2 DC Characteristics

Conditions: Vcc = 5.0V ±10%[*1], AVCC = 5.0V ±10%,[*1] Vss = AVss = 0V,
Ta = -20 to +75°C (Regular Specifications)
Ta = -40 to +85°C (Wide-Range Specifications)

Item		Symbol	Min	Typ	Max	Unit	Measurement Conditions
Input High voltage	$\overline{RES}$, $\overline{STBY}$, MD2, MD1, MD0	VIH	Vcc - 0.7	-	Vcc+0.3	V	
	EXTAL		Vcc × 0.7	-	Vcc+0.3	V	
	Port 8		2.2	-	AVcc+0.3	V	
	Other input pins (except port 7)		2.2	-	Vcc+0.3	V	
Input Low voltage	$\overline{RES}$, $\overline{STBY}$, MD2, MD1, MD0	VIL	-0.3	-	0.5	V	
	Other input pins (except port 7)		-0.3	-	0.8	V	
Schmitt trigger input voltage	Port 7	VT⁻	1.0	-	2.5	V	
		VT+	2.0	-	3.5	V	
		VT+–VT⁻	0.4	-	-	V	
Input leakage current	$\overline{RES}$	| Iin |	-	-	10.0	µA	Vin = 0.5 to Vcc–0.5V
	$\overline{STBY}$, NMI, MD2, MD1, MD0		-	-	1.0	µA	
	port 8		-	-	1.0	µA	Vin = 0.5 to AVcc–0.5V
Leakage current in 3-state (off state)	Port 9, ports 7 to 1	| ITSI |	-	-	1.0	µA	Vin = 0.5 to Vcc–0.5V
Input pull-up MOS current	Ports 6 and 5	–Ip	50	-	200	µA	Vin = 0V
Output High Voltage	All output pins	VOH	Vcc–0.5	-	-	V	IOH = –200µA
			3.5	-	-	V	IOH = –1mA
Output Low Voltage	All output pins	VOL	-	-	0.4	V	IOL = 1.6mA
	Port 4		-	-	1.0	V	IOL = 8mA
			-	-	1.2	V	IOL = 10mA
Input capacitance	$\overline{RES}$	Cin	-	-	60	pF	Vin = 0 V
	NMI		-	-	30	pF	f = 1MHz
	All input pins except $\overline{RES}$, NMI		-	-	15	pF	Ta = 25°C

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

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Table 20-2 DC Characteristics (cont)

Item		Symbol	Min	Typ	Max	Unit	Measurement Conditions
Current dissipation*2	Normal operation	ICC	–	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	AICC	–	1.2	2.0	mA	
	While waiting		–	0.01	5.0	μA	
RAM standby voltage		VRAM	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.
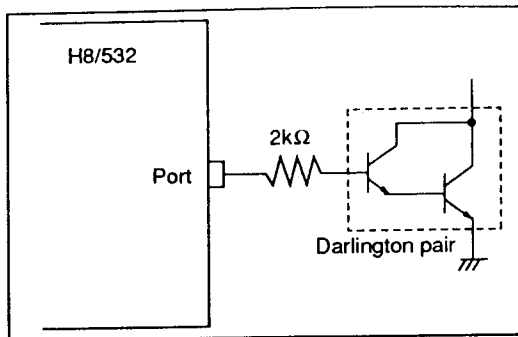
Table 20-3 Allowable Output Current Sink Values

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

Item		Symbol	Min	Typ	Max	Unit
Allowable output Low current sink (per pin)	Port 4	IOL	–	–	10	mA
	Other output pins		–	–	2.0	mA
Allowable output Low current sink (total)	Port 4, total of 8 pins	Σ IOL	–	–	40	mA
	Total of all other output pins		–	–	80	mA
Allowable output High current sink (per pin)	All output pins	–IOH	–	–	2.0	mA
Allowable output High current sink (total)	Total of all output pins	Σ –IOH	–	–	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.

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Figure 20-1 Example of Circuit for Driving a Darlington Transistor Pair
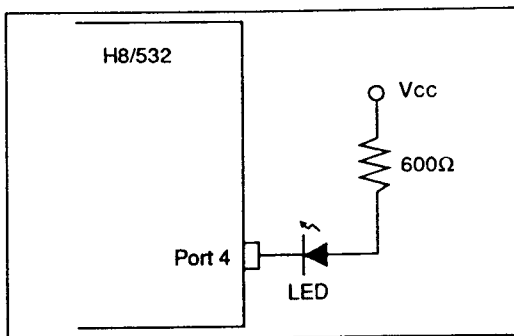
Figure 20-2 Example of Circuit for Driving an LED

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: $V_{CC} = 5.0V \pm 10\%$, $A_{VCC} = 5.0V \pm 10\%$, $\varnothing = 0.5$ 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		8MHz		10MHz		Unit	Measurement Conditions
		Min	Max	Min	Max	Min	Max		
Clock cycle time	tcyc	166.7	2000	125	2000	100	2000	ns	See figure 20-4
Clock pulse width Low	tCL	65	—	45	—	35	—	ns	
Clock pulse width High	tCH	65	—	45	—	35	—	ns	
Clock rise time	tCr	—	15	—	15	—	15	ns	
Clock fall time	tCf	—	15	—	15	—	15	ns	
Address delay time	tAD	—	70	—	65	—	65	ns	
Address hold time	tAH	30	—	25	—	20	—	ns	
Data strobe delay time 1	tDSD1	—	70	—	60	—	40	ns	
Data strobe delay time 2	tDSD2	—	70	—	60	—	50	ns	
Data strobe delay time 3	tDSD3	—	70	—	60	—	50	ns	
Write data strobe pulse width	tDSWW	200	—	150	—	120	—	ns	
Address setup time 1	tAS1	25	—	20	—	15	—	ns	

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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	tAS2	105	–	80	–	65	–	ns	See figure 20-4
Read data setup time	tRDS	60	–	50	–	40	–	ns	
Read data hold time	tRDH	0	–	0	–	0	–	ns	
Read data access time	tACC	–	280	–	190	–	160	ns	
Write data delay time	tWDD	–	70	–	65	–	65	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 20-5
Wait hold time	tWTH	10	–	10	–	10	–	ns	
Bus request setup time	tBRQS	40	–	40	–	40	–	ns	See figure 20-10
Bus acknowledge delay time 1	tBACD1	–	70	–	60	–	55	ns	
Bus acknowledge delay time 2	tBACD2	–	70	–	60	–	55	ns	
Bus floating delay time	tBZD	–	tBACD1	–	tBACD1	–	tBACD1	ns	
E clock delay time	tED	–	20	–	15	–	15	ns	See figure 20-11
E clock rise time	tEr	–	15	–	15	–	15	ns	
E clock fall time	tEf	–	15	–	15	–	15	ns	
Read data hold time (E clock sync)	tRDHE	0	–	0	–	0	–	ns	See figure 20-6
Write data hold time (E clock sync)	tWDHE	50	–	40	–	30	–	ns	

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Table 20-5 Control Signal Timing

Conditions: VCC = 5.0V ±10%, AVCC = 5.0V ±10%, ø = 0.5 to 10MHz, VSS = 0V
Ta = –20 to +75°C (Regular Specifications)
Ta = –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	tRESS	200	–	200	–	200	–	ns	See figure 20-7
$\overline{RES}$ pulse width	tRESW	6.0	–	6.0	–	6.0	–	tcyc	
Mode programming setup time	tMDS	4.0	–	4.0	–	4.0	–	tcyc	
NMI setup time	tNMIS	150	–	150	–	150	–	ns	See figure 20-8
NMI hold time	tNMIH	10	–	10	–	10	–	ns	
$\overline{IRQ}_0$ setup time	tIRQ0S	50	–	50	–	50	–	ns	
$\overline{IRQ}_1$ setup time	tIRQ1S	50	–	50	–	50	–	ns	
$\overline{IRQ}_1$ hold time	tIRQ1H	10	–	10	–	10	–	ns	
NMI pulse width (for recovery from software standby mode)	tNMIW	200	–	200	–	200	–	ns	See figure 20-9
Crystal oscillator settling time (reset)	tOSC1	20	–	20	–	20	–	ms	See figure 20-12
Crystal oscillator settling time (software standby)	tOSC2	10	–	10	–	10	–	ms	See figure 18-1

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

Conditions: $V_{CC} = 5.0V \pm 10\%$, $A_{VCC} = 5.0V \pm 10\%$, $\phi = 0.5$ 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**

5 V

R_L

H8/532 output pin

C = 90pF: P1, P2, P3, P4, P5, P6
  = 30pF: P7, P9
R_L = 2.4kΩ
R_H = 12kΩ
Input/output timing reference levels
Low: 0.8V
High: 2.0V

C R_H
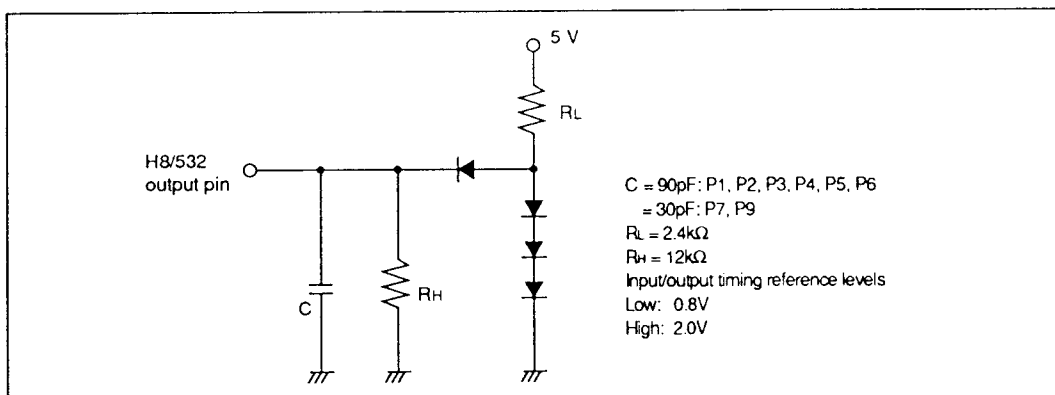
Figure 20-3 Output Load Circuit

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: Vcc = 5.0V ±10%, AVcc = 5.0V ±10%, Vss = AVss = 0V,
                  Ta = –20 to +75°C (Regular Specifications)
                  Ta = –40 to +85°C (Wide-Range Specifications)

Item	6MHz			8MHz			10MHz			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	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

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20.3.1 Bus Timing

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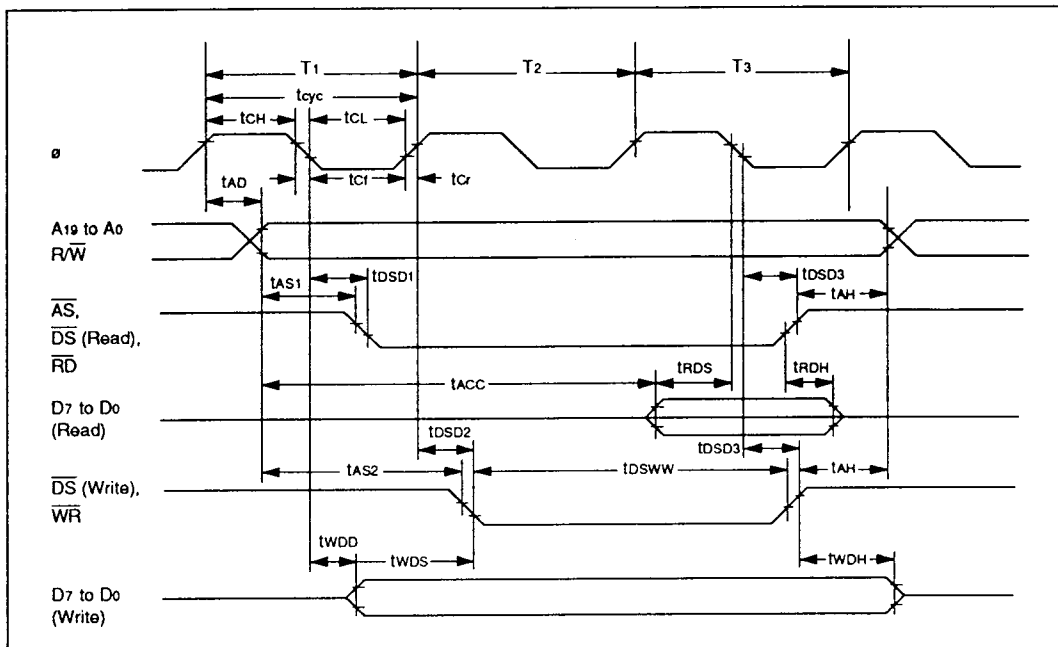
Figure 20-4   Basic Bus Cycle (without Wait States) in Expanded Modes

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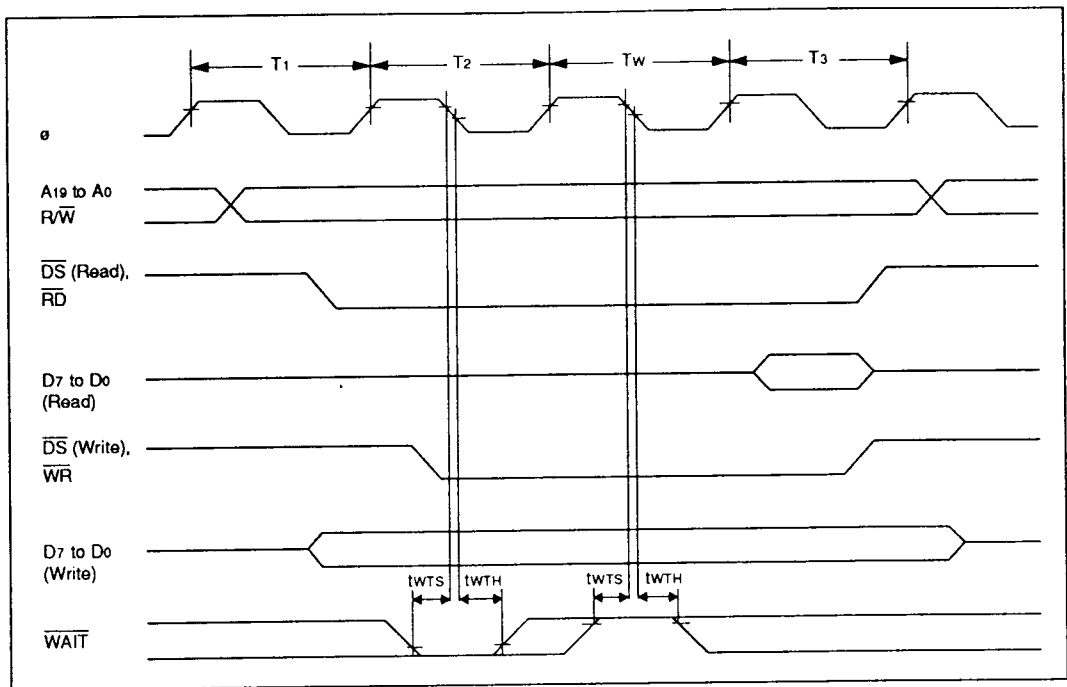
Figure 20-5 Basic Bus Cycle (with 1 Wait State) in Expanded Modes

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3. Bus Cycle Synchronized with E Clock
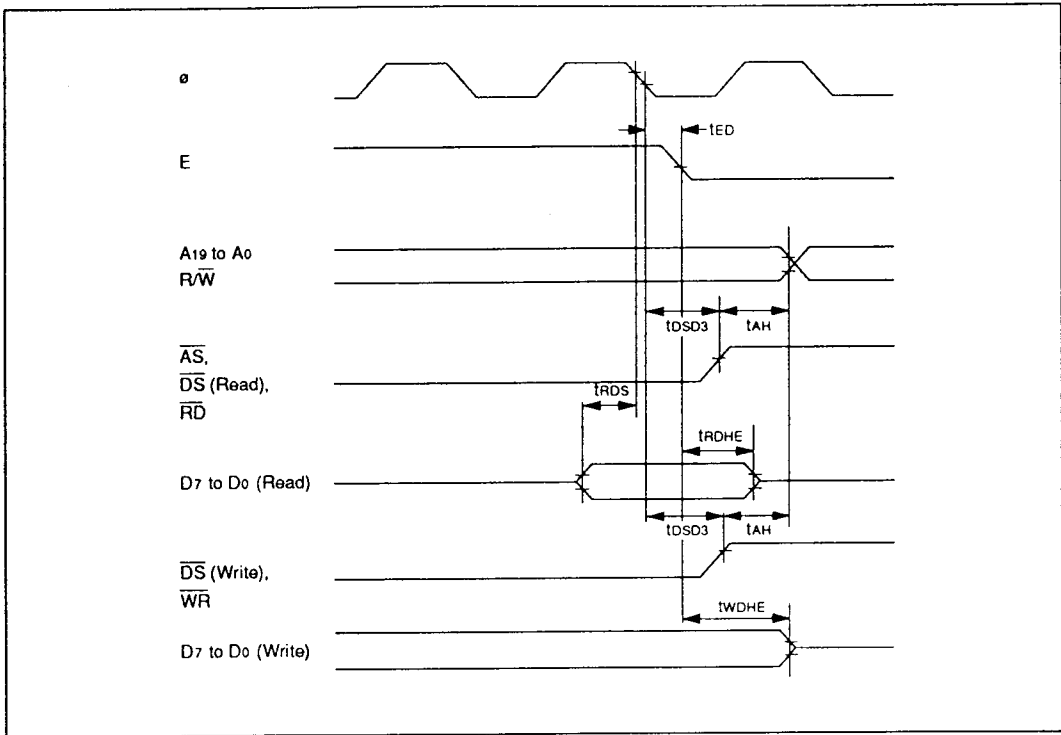
Figure 20-6   Bus Cycle Synchronized with E Clock

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20.3.2 Control Signal Timing

1. Reset Input Timing
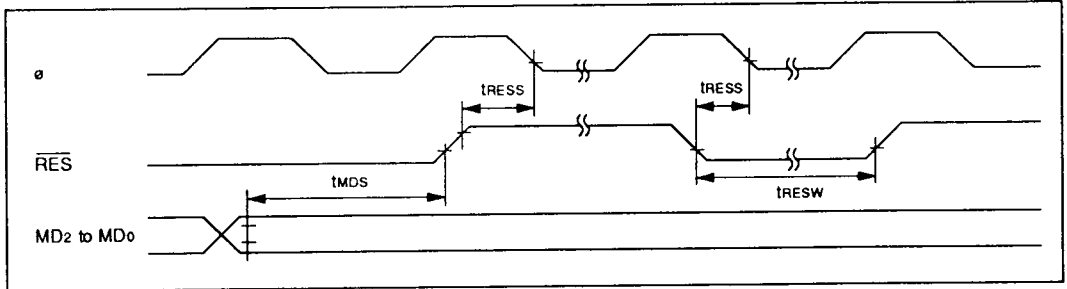
Figure 20-7   Reset Input Timing

2. Interrupt Input Timing
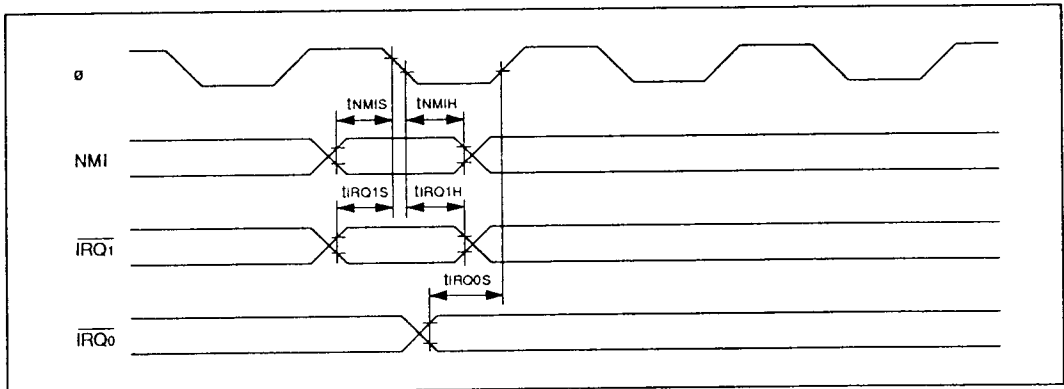
Figure 20-8   Interrupt Input Timing

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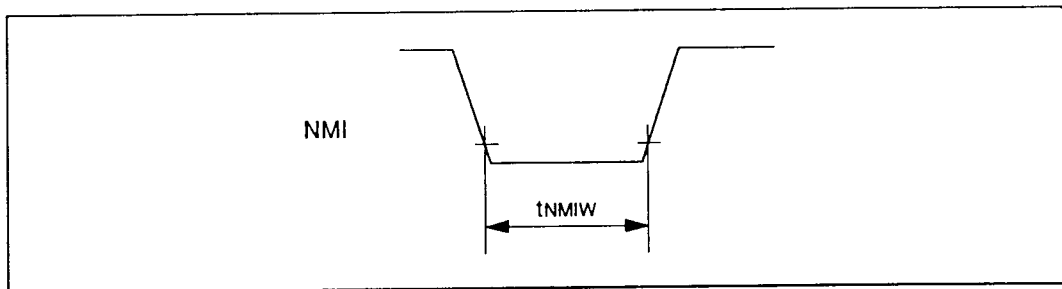
Figure 20-9   NMI Pulse Width (for Recovery from Software Standby Mode)

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4. Bus Release State Timing
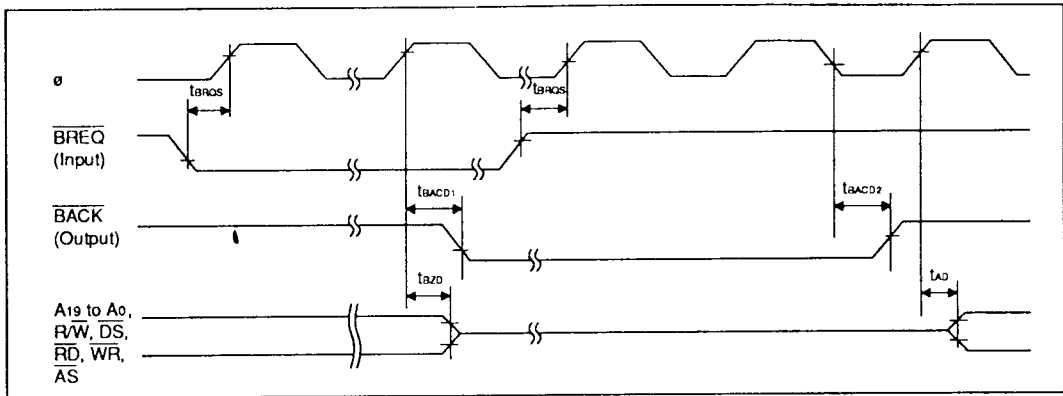
Figure 20-10   Bus Release State Timing

20.3.3 Clock Timing

1. E Clock Timing
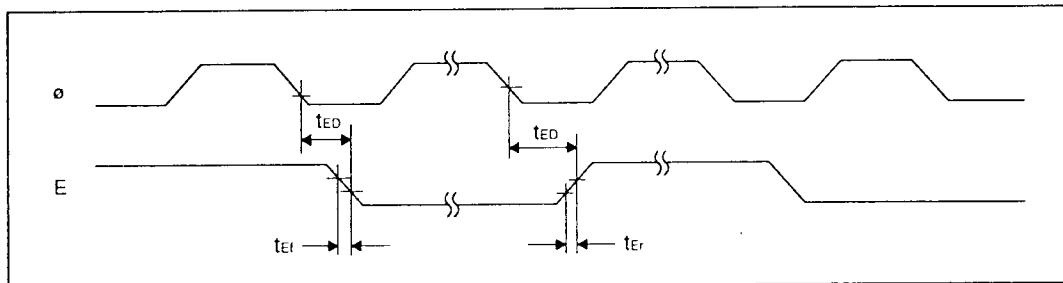
Figure 20-11   E Clock Timing

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2. Clock Oscillator Stabilization Timing
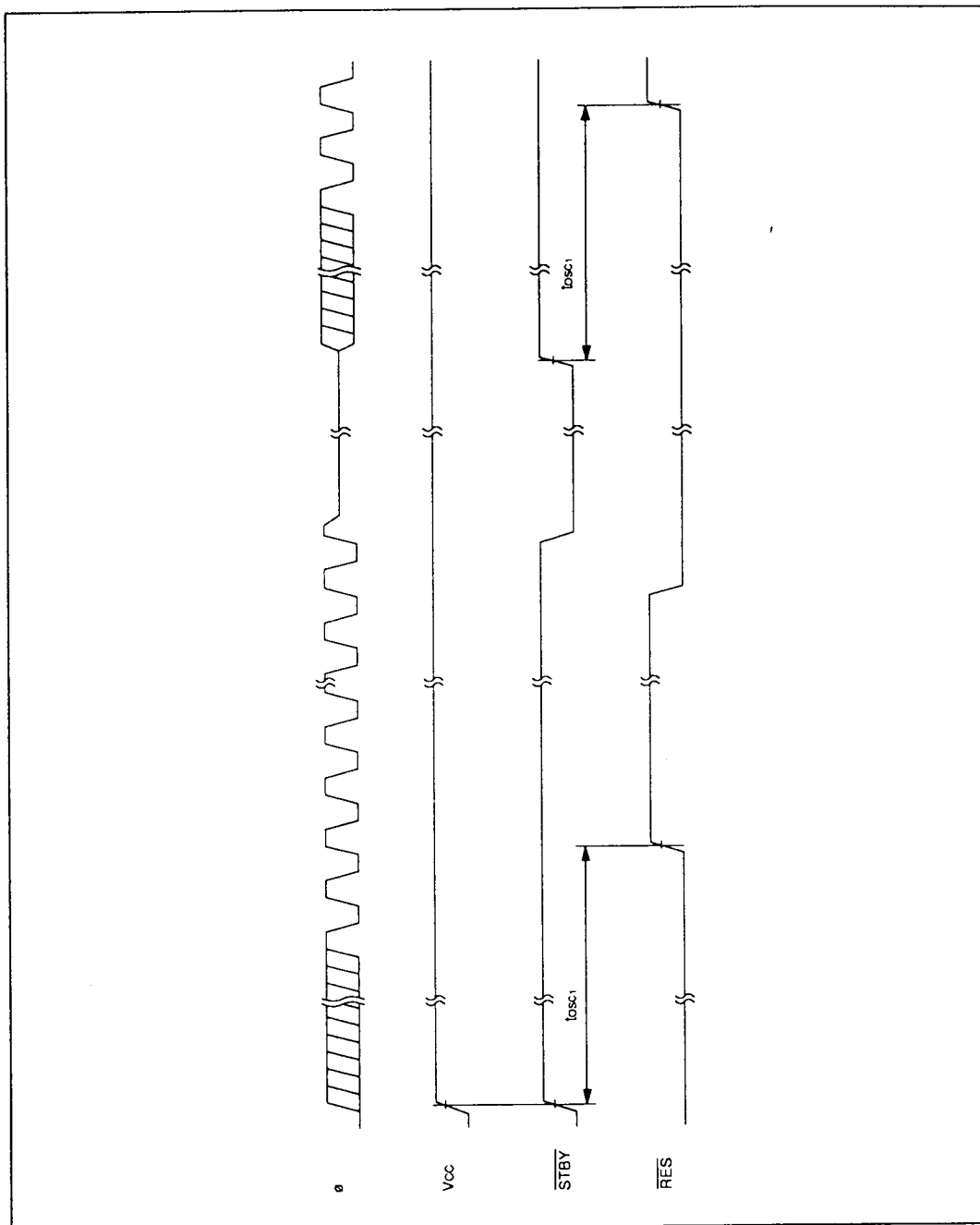
Figure 20-12   Clock Oscillator Stabilization Timing

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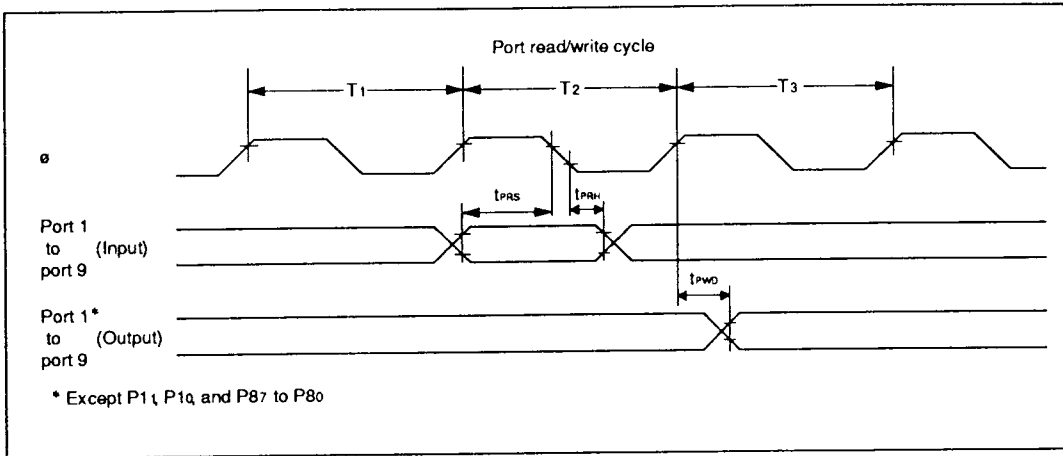
Figure 20-13 I/O Port Input/Output Timing

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20.3.5 16-Bit Free-Running Timer Timing

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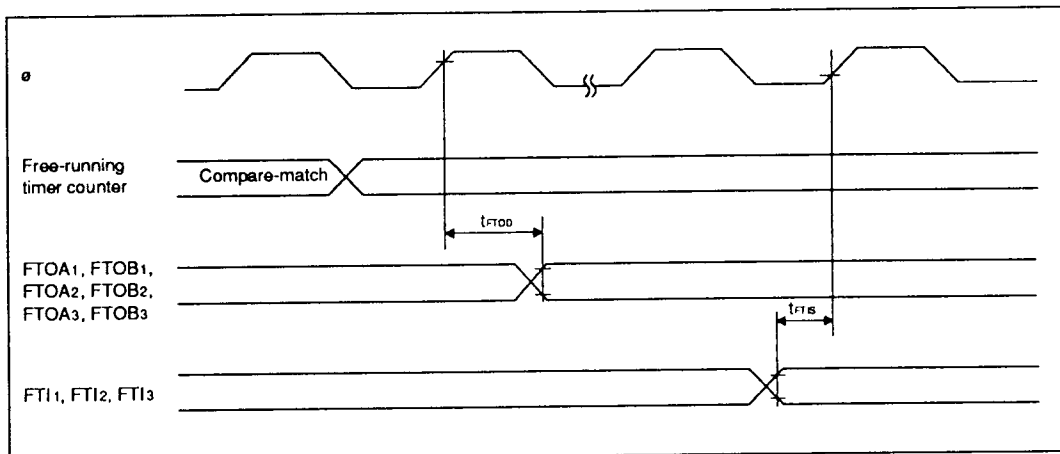
Figure 20-14   Free-Running Timer Input/Output Timing

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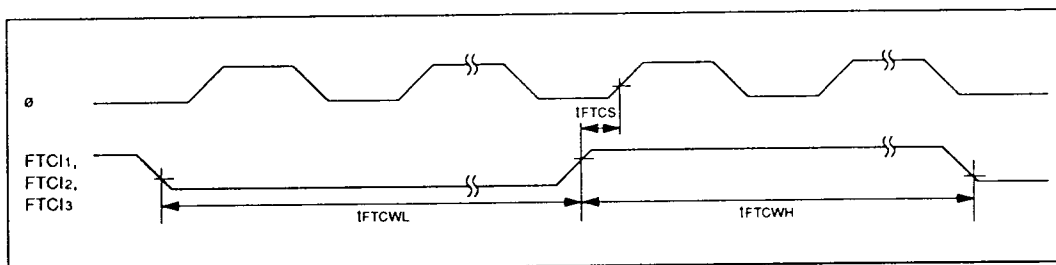
Figure 20-15   External Clock Input Timing for Free-Running Timers

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20.3.6 8-Bit Timer Timing

1. 8-Bit Timer Output Timing
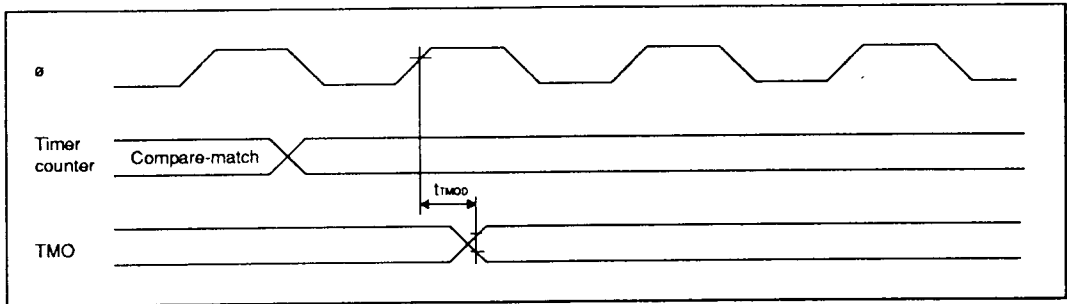
Figure 20-16 8-Bit Timer Output Timing

2. 8-Bit Timer Clock Input Timing
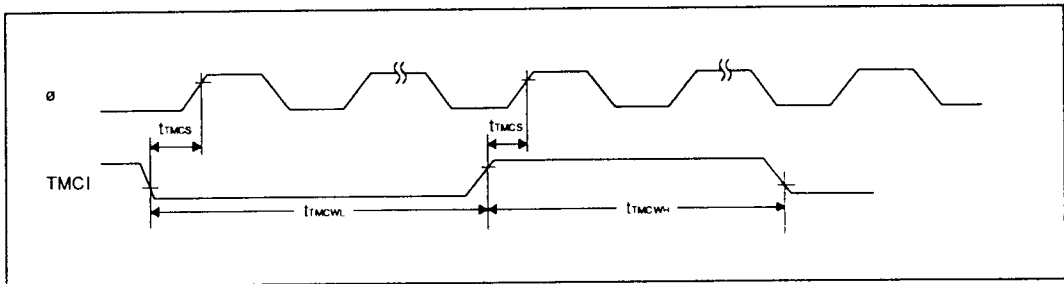
Figure 20-17 8-Bit Timer Clock Input Timing

3. 8-Bit Timer Reset Input Timing
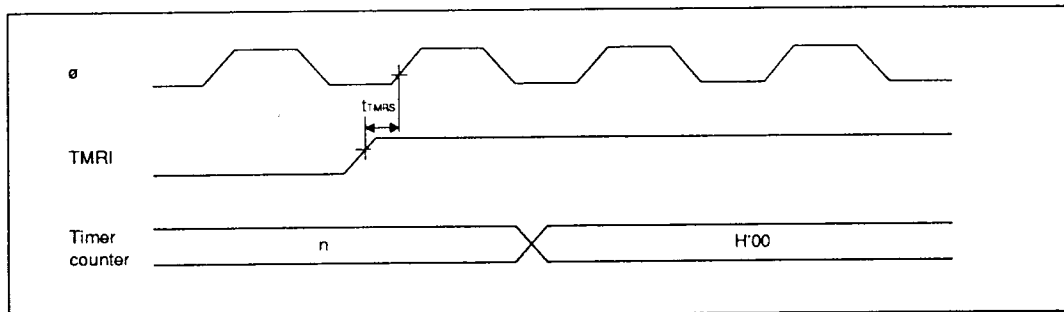
Figure 20-18 8-Bit Timer Reset Input Timing
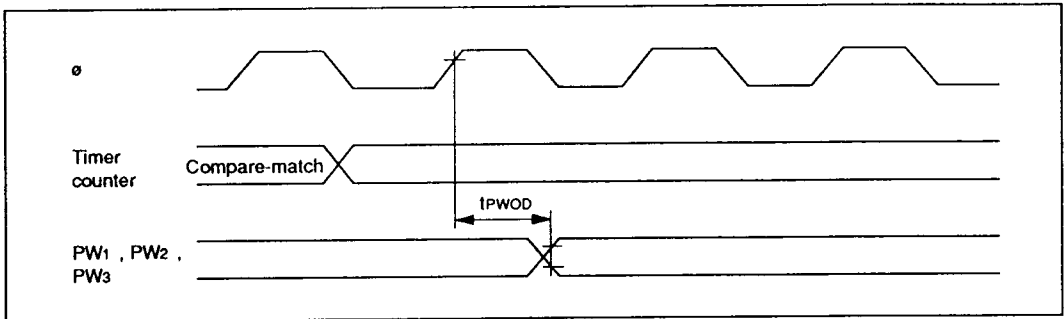
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20.3.7 Pulse Width Modulation Timer Timing

Figure 20-19   PWM Timer Output Timing

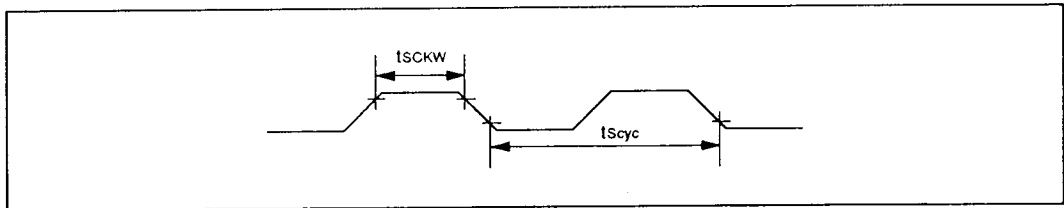### 20.3.8 Serial Communication Interface Timing
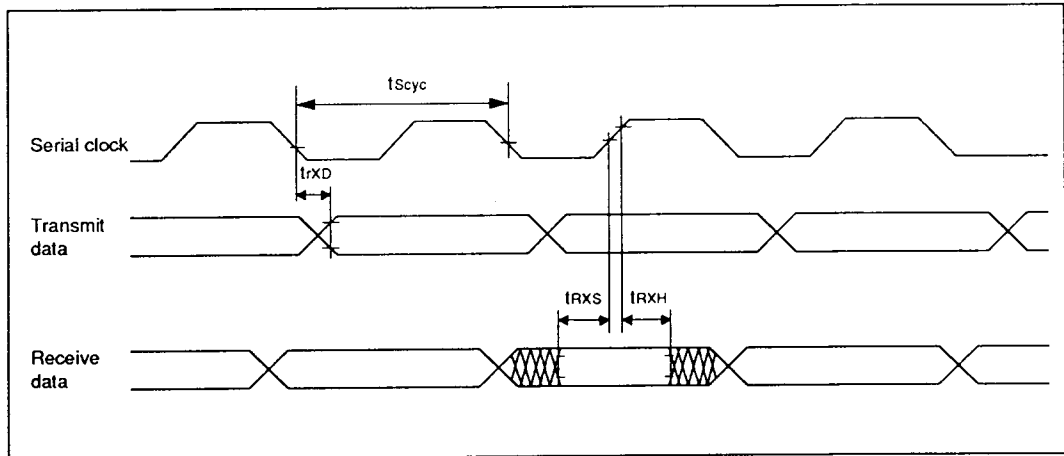

Figure 20-20   SCI Input Clock Timing

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

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