

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	VA _N	-0.3 to AV _{CC} + 0.3	V
Operating temperature	T _{opr}	Regular specifications: -20 to +75 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: $V_{CC} = 5.0V \pm 10\%$ *1, $AV_{CC} = 5.0V \pm 10\%$ *1, $V_{SS} = AV_{SS} = 0V$,
 $T_a = -20$ to $+75^\circ C$ (Regular Specifications)
 $T_a = -40$ to $+85^\circ C$ (Wide-Range Specifications)

Item	Sym- bol	Min	Typ	Max	Unit	Measurement Conditions
Input High voltage	RES, STBY, 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 8		2.2	–	$AV_{CC} + 0.3$	V
	Other input pins (except port 7)		2.2	–	$V_{CC} + 0.3$	V
	RES, STBY, MD2, MD1, MD0	V_{IL}	–0.3	–	0.5	V
Input Low voltage	Other input pins (except port 7)		–0.3	–	0.8	V
	Port 7	V_T	1.0	–	2.5	V
Schmitt trigger input voltage		V_{T+}	2.0	–	3.5	V
		$V_{T+} - V_{T-}$	0.4	–	–	V
	RES	$ I_{in} $	–	–	10.0	μA
Input leakage current	STBY, NMI, MD2, MD1, MD0		–	–	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
			3.5	–	–	V
Output Low Voltage	All output pins	V_{OL}	–	–	0.4	V
			–	–	1.0	V
		Port 4	–	–	1.2	V
						$I_{OH} = -200\mu A$ $I_{OL} = 1.6mA$ $I_{OL} = 8mA$ $I_{OL} = 10mA$
Input capacitance	RES	C_{in}	–	–	60	pF
	NMI		–	–	30	pF
	All input pins except RES, NMI		–	–	15	pF
						$V_{in} = 0V$ $f = 1MHz$ $T_a = 25^\circ C$

Note: *1 AV_{CC} 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	Measurement				
			Min	Typ	Max	Unit	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	T _a ≤ 50°C
			–	–	20	μA	T _a > 50°C
	Analog supply current	During A/D conversion	I _{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	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}	–	–	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.

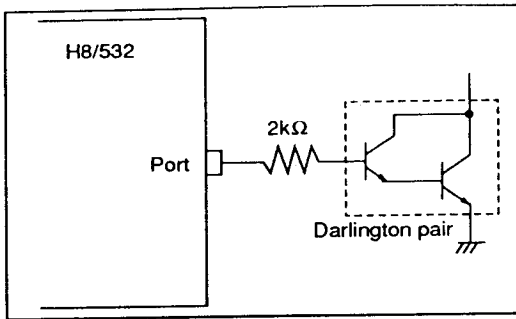


Figure 20-1 Example of Circuit for Driving a Darlington Transistor Pair

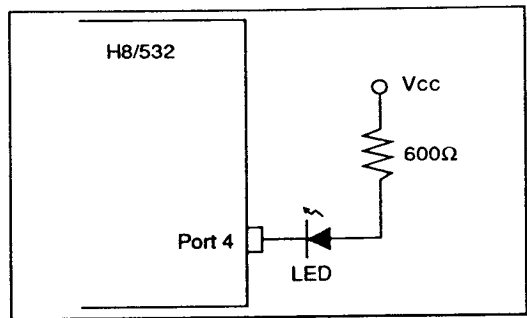


Figure 20-2 Example of Circuit for Driving an LED

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: $V_{CC} = 5.0V \pm 10\%$, $AV_{CC} = 5.0V \pm 10\%$, $\phi = 0.5$ to 10MHz, $V_{SS} = 0V$
 $T_a = -20$ to $+75^\circ C$ (Regular Specifications)
 $T_a = -40$ to $+85^\circ C$ (Wide-Range Specifications)

Item	Symbol	6MHz		8MHz		10MHz		Unit	Measurement Conditions
		Min	Max	Min	Max	Min	Max		
Clock cycle time	t _{cy}	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		8MHz		10MHz		Unit	Measurement Conditions
		Min	Max	Min	Max	Min	Max		
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	

Table 20-5 Control Signal Timing

Conditions: $V_{CC} = 5.0V \pm 10\%$, $AV_{CC} = 5.0V \pm 10\%$, $\phi = 0.5$ to 10MHz, $V_{SS} = 0V$
 $T_a = -20$ to $+75^\circ C$ (Regular Specifications)
 $T_a = -40$ to $+85^\circ C$ (Wide-Range Specifications)

Item	Symbol	6MHz		8MHz		10MHz		Unit	Measurement Conditions
		Min	Max	Min	Max	Min	Max		
\overline{RES} setup time	tRESS	200	–	200	–	200	–	ns	See figure 20-7
\overline{RES} pulse width	tRESW	6.0	–	6.0	–	6.0	–	t _{cyc}	
Mode programming setup time	tMDS	4.0	–	4.0	–	4.0	–	t _{cyc}	
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

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

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

$T_a = -20$ to $+75^\circ C$ (Regular Specifications)

$T_a = -40$ to $+85^\circ C$ (Wide-Range Specifications)

Item	Symbol	6MHz		8MHz		10MHz		Unit	Measurement Conditions		
		Min	Max	Min	Max	Min	Max				
FRT	Timer output delay time	tFTOD	–	100	–	100	–	100	ns	See figure 20-14	
	Timer input setup time	tFTIS	50	–	50	–	50	–	ns		
	Timer clock input setup time	tFTCS	50	–	50	–	50	–	ns	See figure 20-15	
	Timer clock pulse width	tFTCWL, tFTCWH	1.5	–	1.5	–	1.5	–	t _{cy}		
TMR	Timer output delay time	tTMOD	–	100	–	100	–	100	ns	See figure 20-16	
	Timer clock input setup time	tTMCS	50	–	50	–	50	–	ns	See figure 20-17	
	Timer clock pulse width	tTMCWL, tTMCWH	1.5	–	1.5	–	1.5	–	t _{cy}		
	Timer reset input setup time	tTMRS	50	–	50	–	50	–	ns	See figure 20-18	
PWM	Timer output delay time	tPWOD	–	100	–	100	–	100	ns	See figure 20-19	
SCI	Input clock cycle	(Async) (Sync)	t _{Scyc}	2	–	2	–	2	–	t _{cy}	See figure 20-20
	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)	tTXD	–	100	–	100	–	100	ns	See figure 20-21
	Receive data setup time	(Sync)	tRXS	100	–	100	–	100	–	ns	
	Receive data hold time	(Sync)	tRXH	100	–	100	–	100	–	ns	
Port	Output data delay time	tPWD	–	100	–	100	–	100	ns	See figure 20-13	
	Input data setup time	tPRS	50	–	50	–	50	–	ns		
	Input data hold time	tPRH	50	–	50	–	50	–	ns		

• Measurement Conditions for AC Characteristics

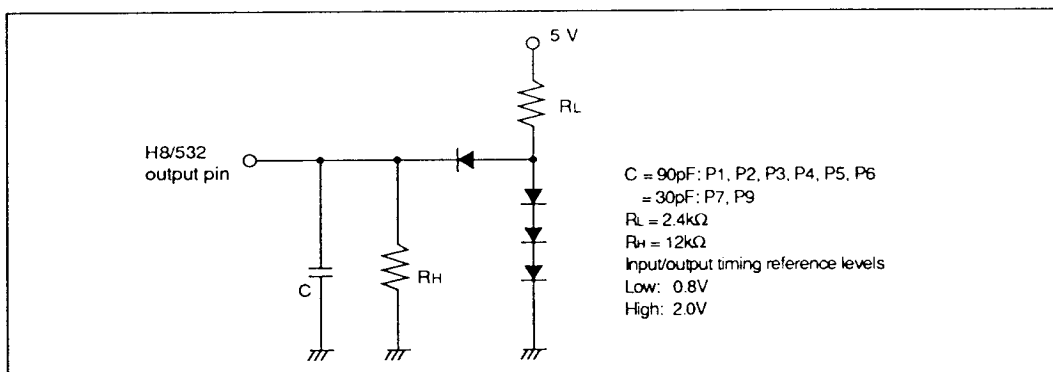


Figure 20-3 Output Load Circuit

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: $V_{CC} = 5.0V \pm 10\%$, $AV_{CC} = 5.0V \pm 10\%$, $V_{SS} = AV_{SS} = 0V$,
 $T_a = -20$ to $+75^\circ C$ (Regular Specifications)
 $T_a = -40$ to $+85^\circ C$ (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	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

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 Interface Timing	Figure 20-20 and 20-21

20.3.1 Bus Timing

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

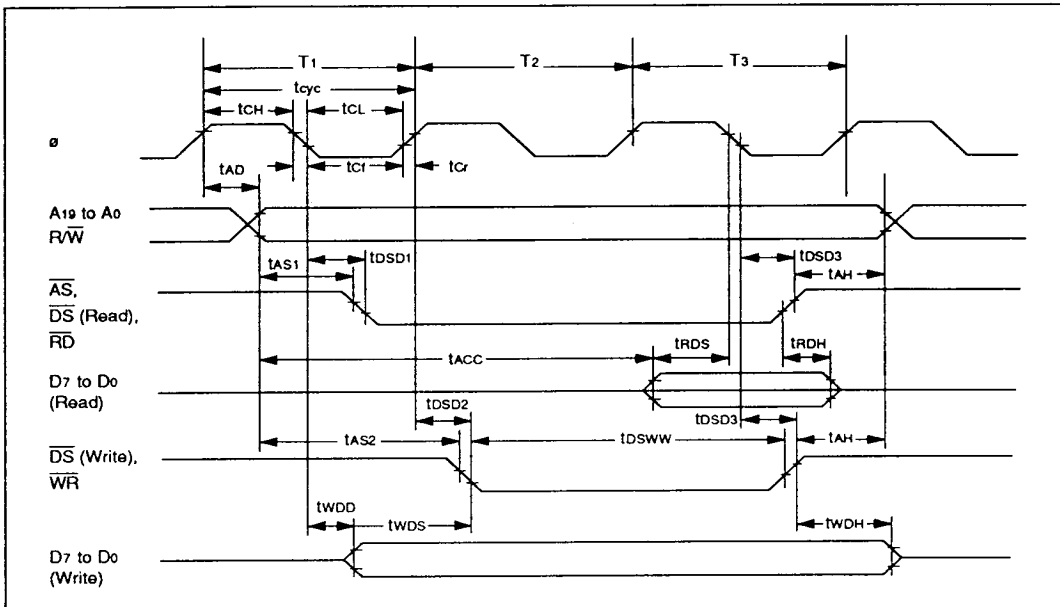


Figure 20-4 Basic Bus Cycle (without Wait States) in Expanded Modes

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

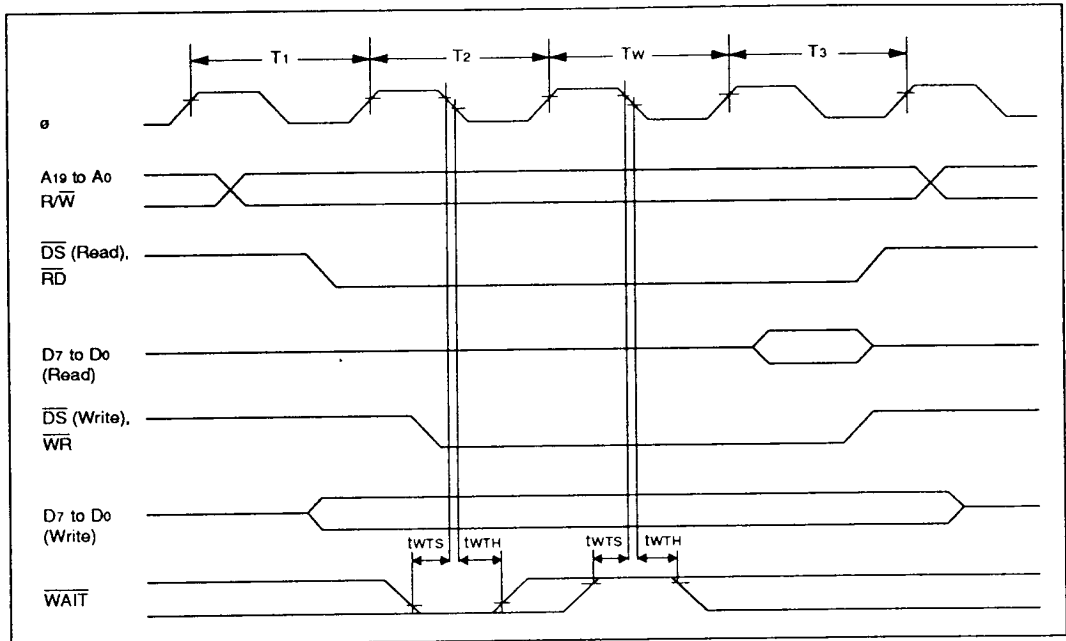


Figure 20-5 Basic Bus Cycle (with 1 Wait State) in Expanded Modes

3. Bus Cycle Synchronized with E Clock

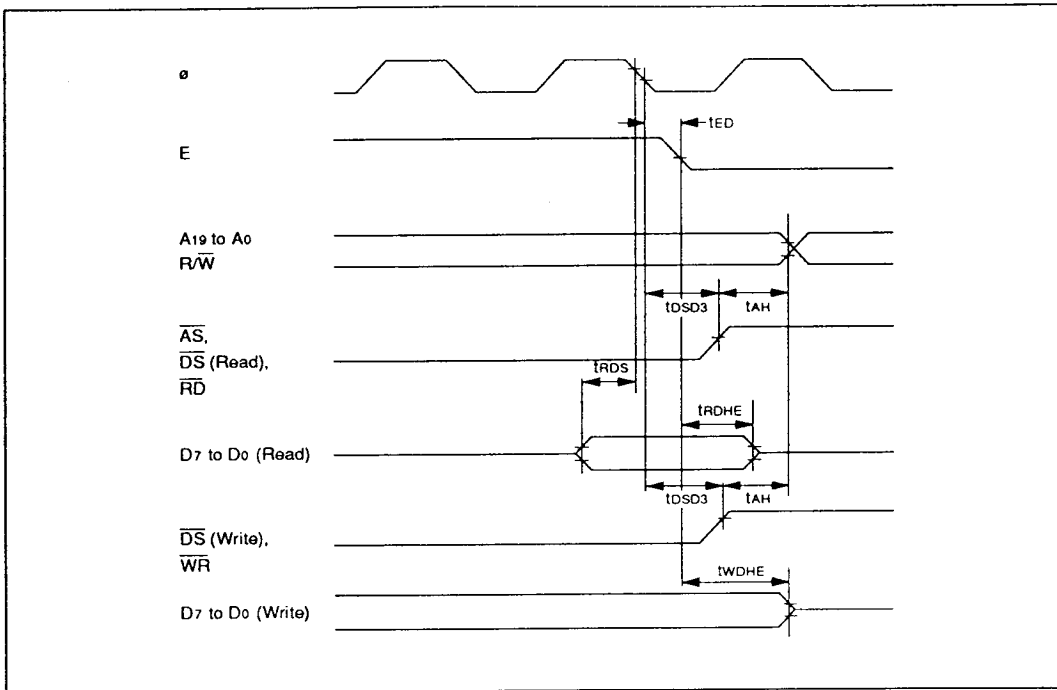


Figure 20-6 Bus Cycle Synchronized with E Clock

20.3.2 Control Signal Timing

1. Reset Input Timing

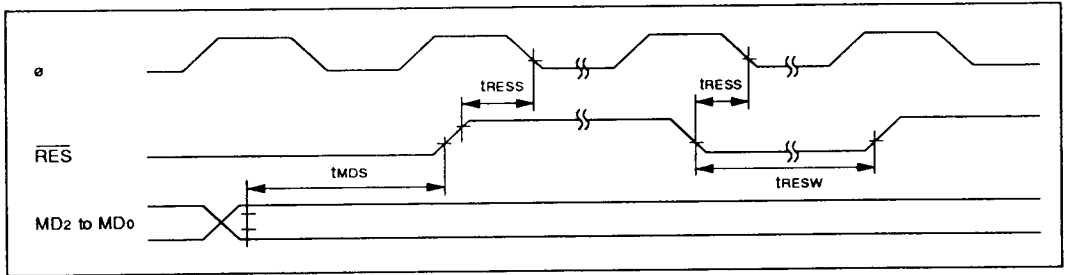


Figure 20-7 Reset Input Timing

2. Interrupt Input Timing

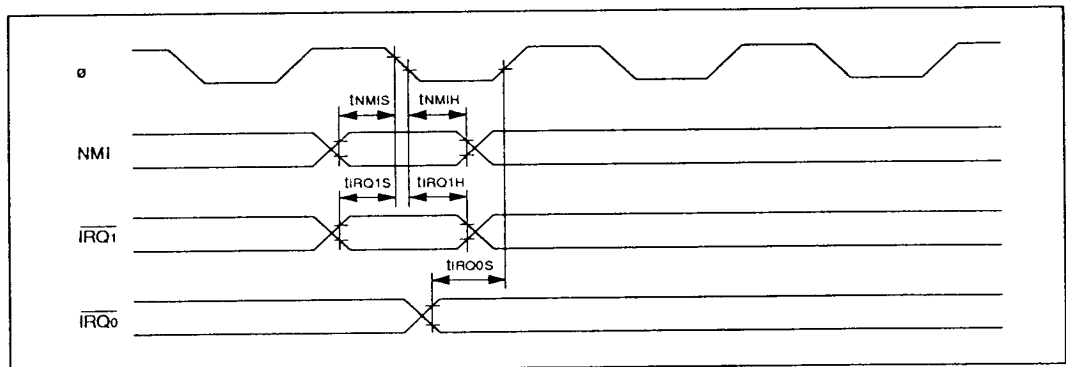


Figure 20-8 Interrupt Input Timing

3. NMI Pulse Width

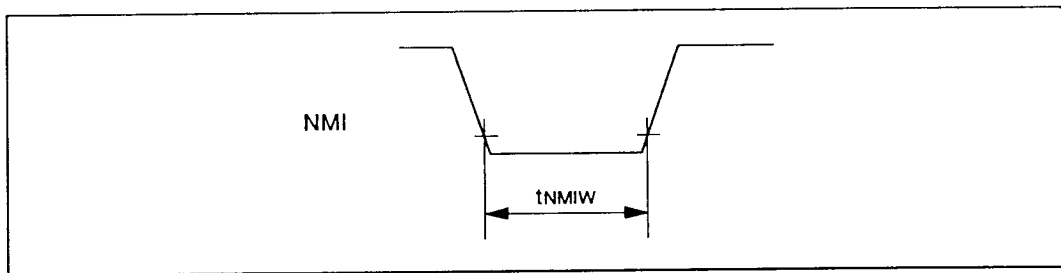


Figure 20-9 NMI Pulse Width (for Recovery from Software Standby Mode)

4. Bus Release State Timing

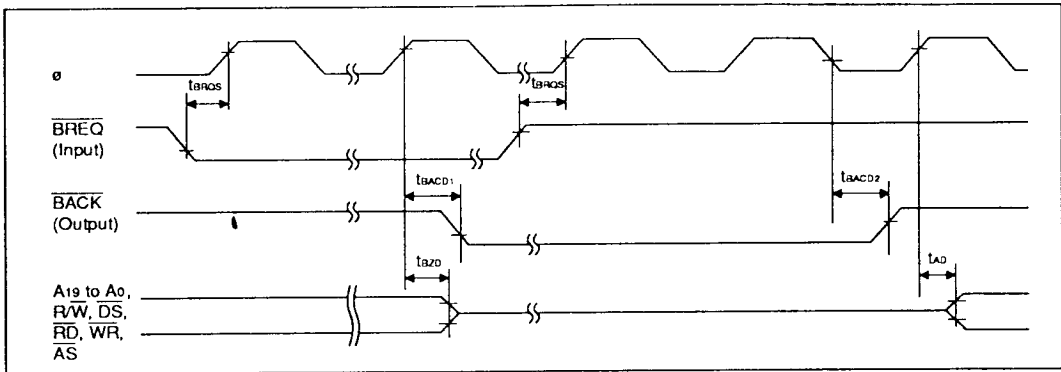


Figure 20-10 Bus Release State Timing

20.3.3 Clock Timing

1. E Clock Timing

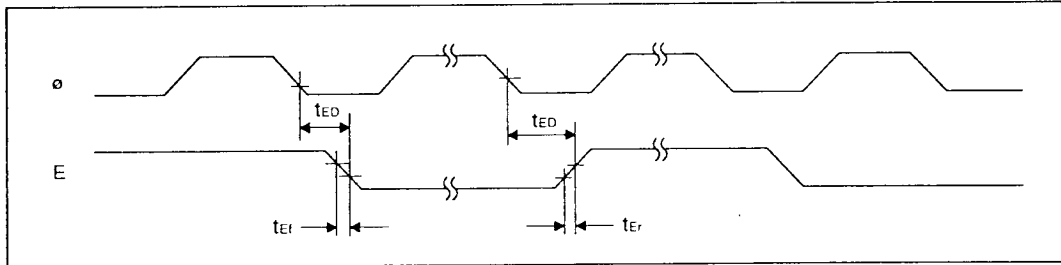


Figure 20-11 E Clock Timing

2. Clock Oscillator Stabilization Timing

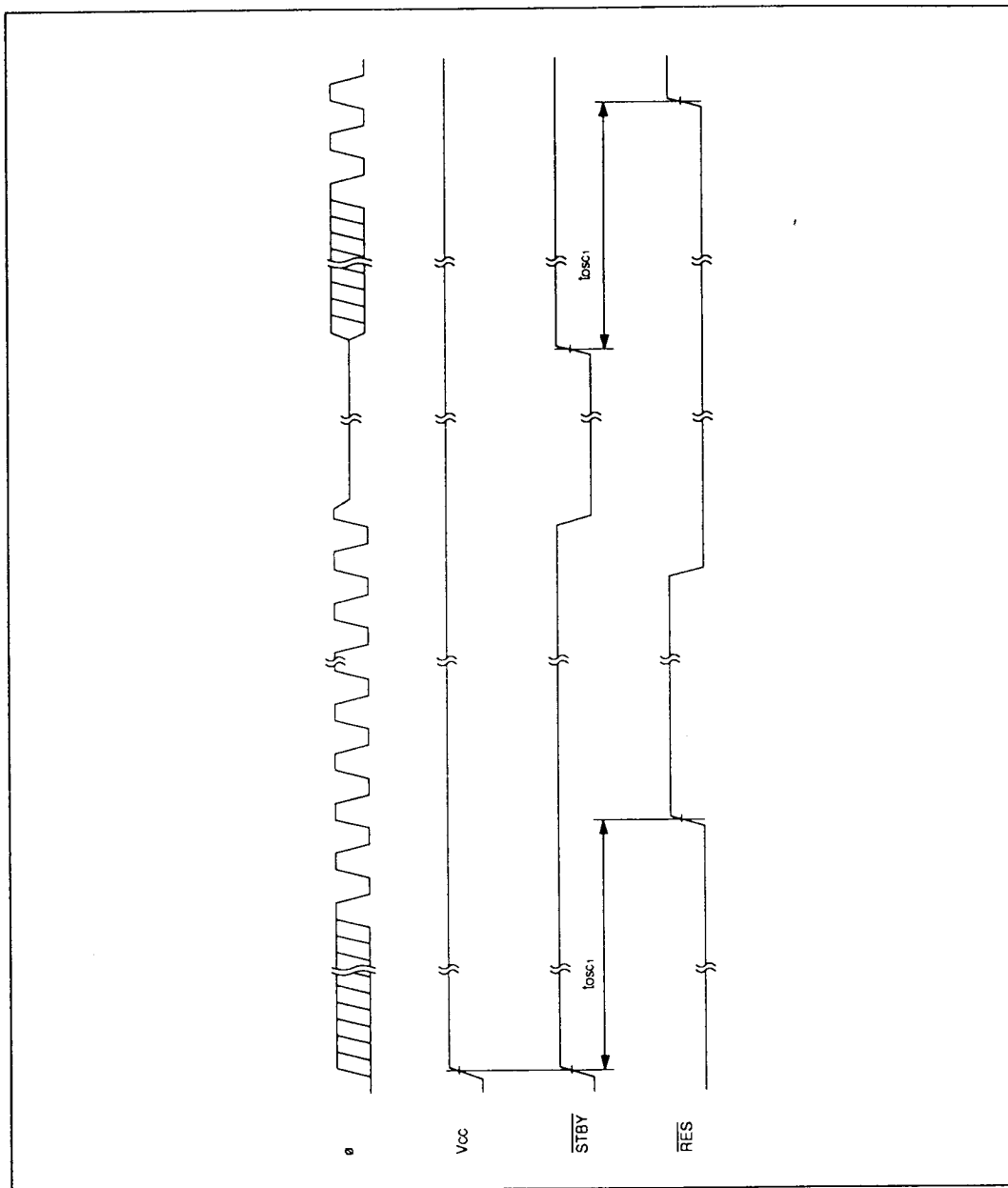


Figure 20-12 Clock Oscillator Stabilization Timing

20.3.4 I/O Port Timing

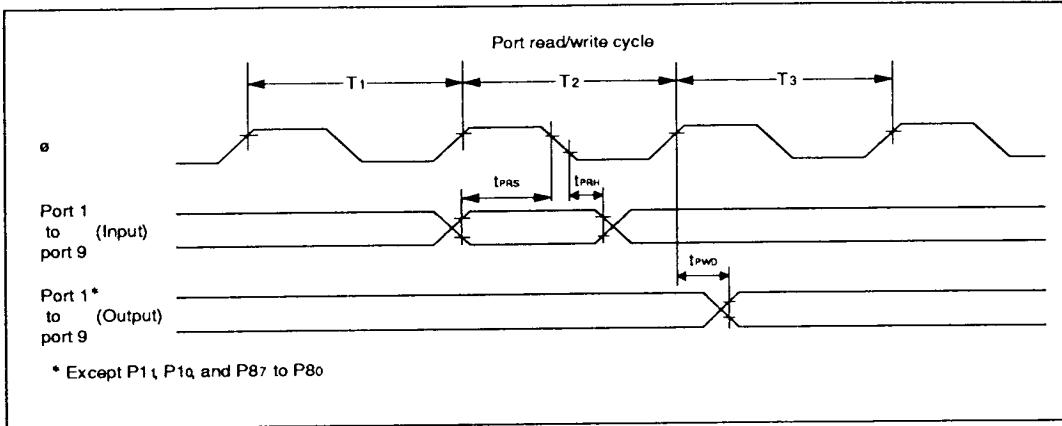


Figure 20-13 I/O Port Input/Output Timing

20.3.5 16-Bit Free-Running Timer Timing

1. Free-Running Timer Input/Output Timing

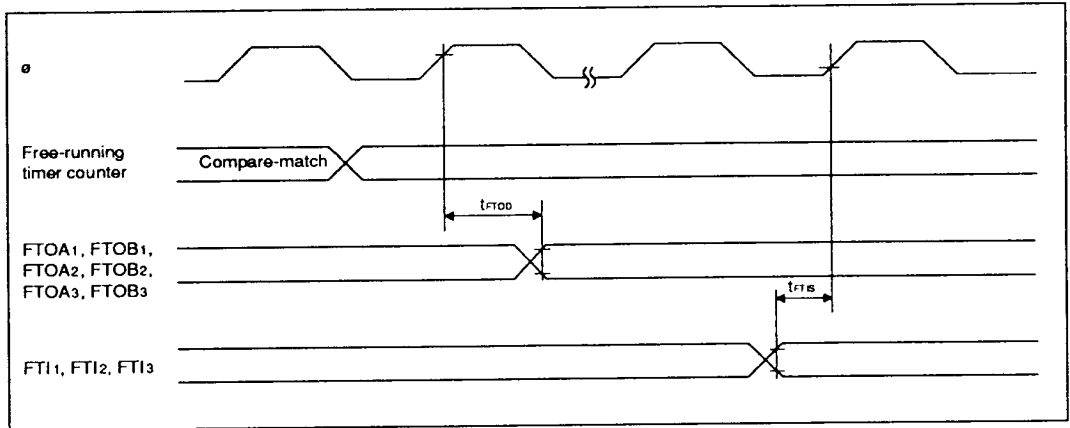


Figure 20-14 Free-Running Timer Input/Output Timing

2. External Clock Input Timing for Free-Running Timers

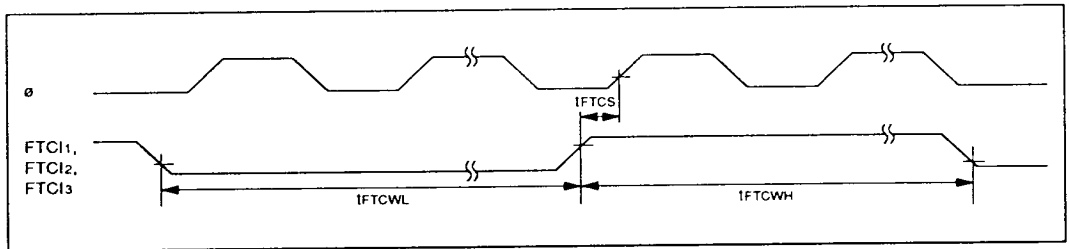


Figure 20-15 External Clock Input Timing for Free-Running Timers

20.3.6 8-Bit Timer Timing

1. 8-Bit Timer Output Timing

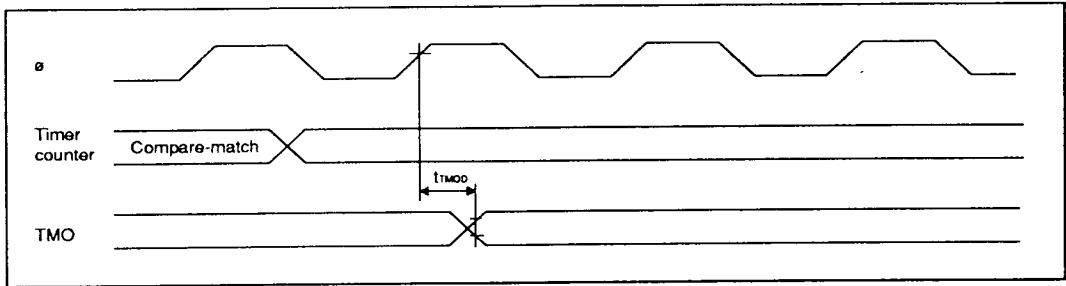


Figure 20-16 8-Bit Timer Output Timing

2. 8-Bit Timer Clock Input Timing

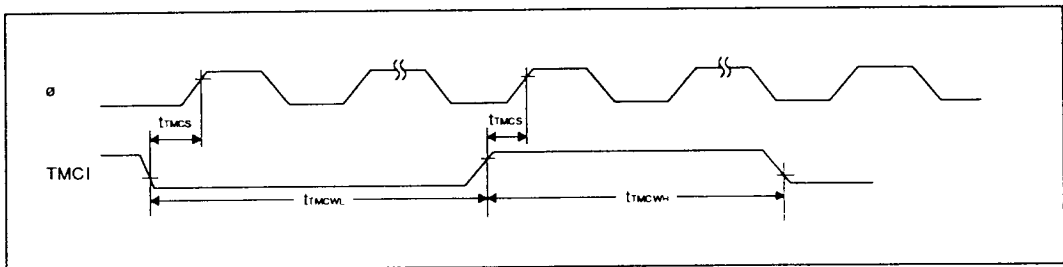


Figure 20-17 8-Bit Timer Clock Input Timing

3. 8-Bit Timer Reset Input Timing

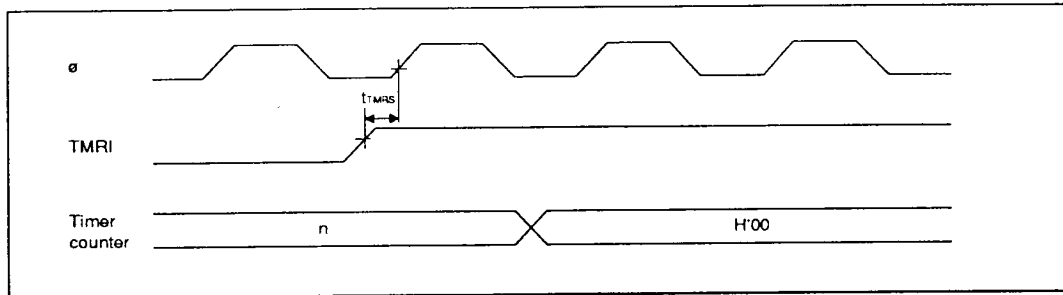


Figure 20-18 8-Bit Timer Reset Input Timing

20.3.7 Pulse Width Modulation Timer Timing

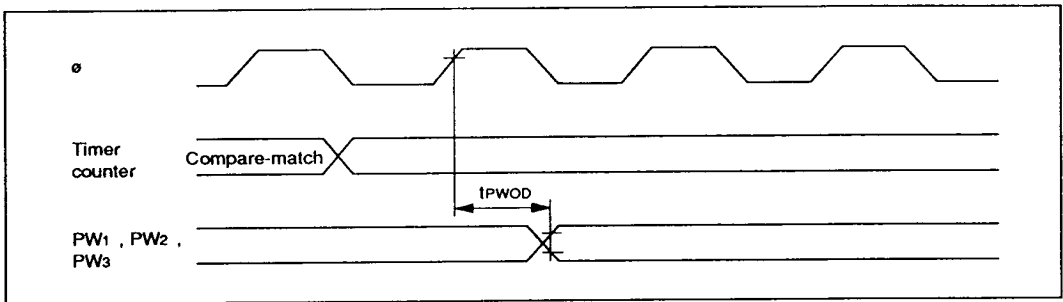


Figure 20-19 PWM Timer Output Timing

20.3.8 Serial Communication Interface Timing

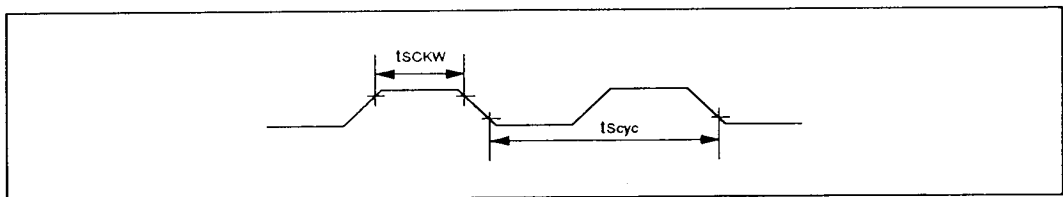


Figure 20-20 SCI Input Clock Timing

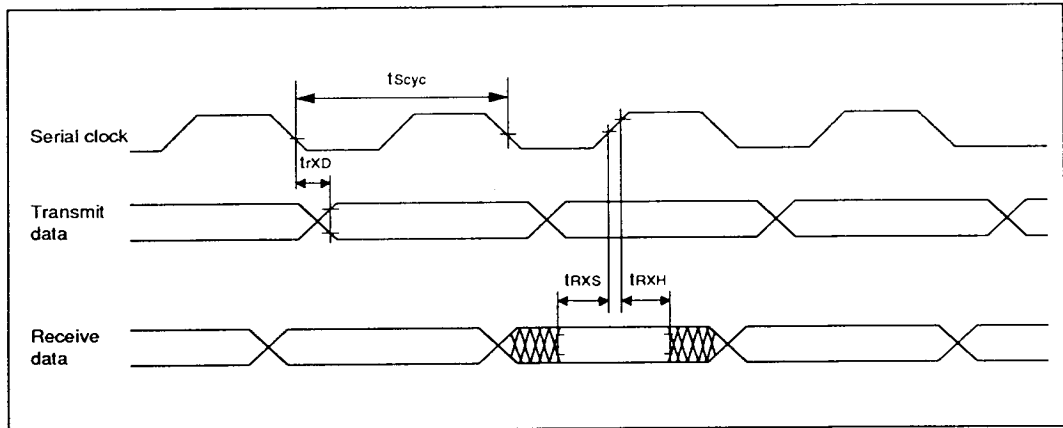


Figure 20-21 SCI Input/Output Timing (Synchronous Mode)