

## MC68LK332

*Technical Supplement***16.78 MHz Electrical Characteristics**

Devices in the 68300 Modular Microcontroller Family are built up from a selection of standard functional modules. The MC68LK332 incorporates a central processing unit (CPU32), a system integration module (SIM), a queued serial module (QSM), a time processor unit (TPU), and a 2 K-byte static RAM module with TPU emulation capability (TPURAM). The functionality of the MC68LK332 is enhanced from the MC68L332 to include an operational PLL.

This publication contains a new electrical characteristics appendix for the MC68LK332 to be used in conjunction with the *MC68332 User's Manual* (MC68332UM/AD).

**PRELIMINARY**

**LIST OF ILLUSTRATIONS**

<b>Figure</b>	<b>Title</b>	<b>Page</b>
1	CLKOUT Output Timing Diagram .....	12
2	External Clock Input Timing Diagram .....	12
3	ECLK Output Timing Diagram .....	12
4	Read Cycle Timing Diagram .....	13
5	Write Cycle Timing Diagram .....	14
6	Fast Termination Read Cycle Timing Diagram .....	15
7	Fast Termination Write Cycle Timing Diagram .....	16
8	Bus Arbitration Timing Diagram — Active Bus Case .....	17
9	Bus Arbitration Timing Diagram — Idle Bus Case .....	18
10	Show Cycle Timing Diagram .....	19
11	Chip-Select Timing Diagram .....	20
12	Reset and Mode Select Timing Diagram .....	20
13	BDM Serial Communication Timing Diagram .....	21
14	BDM Freeze Assertion Timing Diagram .....	21
15	ECLK Timing Diagram .....	23
16	QSPI Timing — Master, CPHA = 0 .....	25
17	QSPI Timing — Master, CPHA = 1 .....	25
18	QSPI Timing — Slave, CPHA = 0 .....	26
19	QSPI Timing — Slave, CPHA = 1 .....	26
20	TPU Timing Diagram .....	27



**LIST OF TABLES**

<b>Table</b>	<b>Title</b>	<b>Page</b>
1	Maximum Ratings .....	4
2	MC68LK332 Typical Ratings .....	5
3	Thermal Characteristics .....	5
4	Clock Control Timing .....	6
5	16.78 MHz DC Characteristics .....	7
6	16.78 MHz AC Timing .....	9
7	Background Debugging Mode Timing .....	21
8	ECLK Bus Timing .....	22
9	QSPI Timing .....	24
10	Time Processor Unit Timing .....	27

**Table 1 Maximum Ratings**

Num	Rating	Symbol	Value	Unit
1	Supply Voltage <sup>1, 2, 3</sup>	$V_{DD}$	- 0.3 to + 6.5	V
2	Input Voltage <sup>1, 2, 3, 4, 5, 7</sup>	$V_{IN}$	- 0.3 to + 6.5	V
3	Instantaneous Maximum Current Single Pin Limit (all pins) <sup>1, 3, 5, 6</sup>	$I_D$	25	mA
4	Operating Maximum Current Digital Input Disruptive Current <sup>3, 5, 6, 7, 8</sup> $V_{NEGCLAMP} \cong -0.3\text{ V}$ $V_{POSCLAMP} \cong V_{DD} + 0.3$	$I_{id}$	- 500 to 500	$\mu\text{A}$
5	Operating Temperature Range C Suffix	$T_A$	$T_L$ to $T_H$ - 40 to 85	$^{\circ}\text{C}$
6	Storage Temperature Range	$T_{stg}$	- 55 to 150	$^{\circ}\text{C}$

**NOTES:**

1. Permanent damage can occur if maximum ratings are exceeded. Exposure to voltages or currents in excess of recommended values affects device reliability. Device modules may not operate normally while being exposed to electrical extremes.
2. Although sections of the device contain circuitry to protect against damage from high static voltages or electrical fields, take normal precautions to avoid exposure to voltages higher than maximum-rated voltages.
3. This parameter is periodically sampled rather than 100% tested.
4. All pins except TSC.
5. Input must be current limited to the value specified. To determine the value of the required current-limiting resistor, calculate resistance values for positive and negative clamp voltages, then use the larger of the two values.
6. Power supply must maintain regulation within operating  $V_{DD}$  range during instantaneous and operating maximum current.
7. All functional non-supply pins are internally clamped to  $V_{SS}$ . All functional pins except EXTAL and XFC are internally clamped to  $V_{DD}$ .
8. Total input current for all digital input-only and all digital input/output pins must not exceed 10 mA. Exceeding this limit can cause disruption of normal operation.

**Table 2 MC68LK332 Typical Ratings**

Num	Rating	Symbol	Value	Unit
1	Supply Voltage	$V_{DD}$	3.3	V
2	Operating Temperature	$T_A$	25	°C
3	$V_{DD}$ Supply Current	$I_{DD}$	45	mA
	RUN		125	μA
	LPSTOP, VCO off LPSTOP, External clock, max $f_{sys}$		1.0	mA
4	Clock Synthesizer Operating Voltage	$V_{DDSYN}$	3.3	V
5	$V_{DDSYN}$ Supply Current	$I_{DDSYN}$	1.0	mA
	VCO on, maximum $f_{sys}$		2.0	mA
	External Clock, maximum $f_{sys}$		100	μA
	LPSTOP, VCO off $V_{DD}$ powered down		50	μA
6	RAM Standby Current	$I_{SB}$	3.0	μA
	Normal RAM operation Standby operation		10	μA
7	Power Dissipation	$P_D$	148.0	mW

**Table 3 Thermal Characteristics**

Num	Rating	Symbol	Value	Unit
1	Thermal Resistance	$\Theta_{JA}$	38	°C/W
	Plastic 132-Pin Surface Mount		49	
	Plastic 144-Pin Surface Mount			

The average chip-junction temperature ( $T_J$ ) in C can be obtained from:

$$T_J = T_A + (P_D \times \Theta_{JA}) \quad (1)$$

where:

$T_A$  = Ambient Temperature, °C

$\Theta_{JA}$  = Package Thermal Resistance, Junction-to-Ambient, °C/W

$P_D$  =  $P_{INT} + P_{I/O}$

$P_{INT}$  =  $I_{DD} \times V_{DD}$ , Watts — Chip Internal Power

$P_{I/O}$  = Power Dissipation on Input and Output Pins — User Determined

For most applications  $P_{I/O} < P_{INT}$  and can be neglected. An approximate relationship between  $P_D$  and  $T_J$  (if  $P_{I/O}$  is neglected) is:

$$P_D = K + (T_J + 273^\circ\text{C}) \quad (2)$$

Solving equations 1 and 2 for K gives:

$$K = P_D \times (T_A + 273^\circ\text{C}) + \Theta_{JA} \times P_D^2 \quad (3)$$

where K is a constant pertaining to the particular part. K can be determined from equation (3) by measuring  $P_D$  (at equilibrium) for a known  $T_A$ . Using this value of K, the values of  $P_D$  and  $T_J$  can be obtained by solving equations (1) and (2) iteratively for any value of  $T_A$ .

**Table 4 Clock Control Timing**
 $(V_{DD} \text{ and } V_{DDSYN} = 3.0 \text{ to } 3.6 \text{ Vdc, } V_{SS} = 0 \text{ Vdc, } T_A = T_L \text{ to } T_H)$ 

Num	Characteristic	Symbol	Min	Max	Unit
1	PLL Reference Frequency Range	$f_{ref}$	20	50	kHz
2	System Frequency <sup>1</sup> On-Chip PLL System Frequency External Clock Operation	$f_{sys}$	$4(f_{ref})$ dc	16.78 16.78	MHz
3	PLL Lock Time <sup>2, 3, 4, 5</sup>	$t_{pll}$	—	20	ms
4	VCO Frequency <sup>6</sup>	$f_{VCO}$	—	$2 (f_{sys} \text{ max})$	MHz
5	CLKOUT Jitter <sup>2, 3, 4, 7</sup> Short term (5 $\mu$ s interval) Long term (500 $\mu$ s interval)	$J_{clk}$	-1.0 -0.5	1.0 0.5	%

**NOTES:**

- All internal registers retain data at 0 Hz.
- This parameter is periodically sampled rather than 100% tested.
- Assumes that a low-leakage external filter network is used to condition clock synthesizer input voltage. Total external resistance from the XFC pin due to external leakage must be greater than 15 M $\Omega$  to guarantee this specification. Filter network geometry can vary depending upon operating environment.
- Proper layout procedures must be followed to achieve specifications.
- Assumes that stable  $V_{DDSYN}$  is applied, and that the crystal oscillator is stable. Lock time is measured from the time  $V_{DD}$  and  $V_{DDSYN}$  are valid until  $\overline{RESET}$  is released. This specification also applies to the period required for PLL lock after changing the W and Y frequency control bits in the synthesizer control register (SYNCR) while the PLL is running, and to the period required for the clock to lock after LPSTOP.
- Internal VCO frequency ( $f_{VCO}$ ) is determined by SYNCR W and Y bit values. The SYNCR X bit controls a divide-by-two circuit that is not in the synthesizer feedback loop. When  $X = 0$ , the divider is enabled, and  $f_{sys} = f_{VCO} \div 4$ . When  $X = 1$ , the divider is disabled, and  $f_{sys} = f_{VCO} \div 2$ . X must equal one when operating at maximum specified  $f_{sys}$ .
- Jitter is the average deviation from the programmed frequency measured over the specified interval at maximum  $f_{sys}$ . Measurements are made with the device powered by filtered supplies and clocked by a stable external clock signal. Noise injected into the PLL circuitry via  $V_{DDSYN}$  and  $V_{SS}$  and variation in crystal oscillator frequency increase the  $J_{clk}$  percentage for a given interval. When jitter is a critical constraint on control system operation, this parameter should be measured during functional testing of the final system.

**Table 5 16.78 MHz DC Characteristics**  
 ( $V_{DD}$  and  $V_{DDSYN} = 3.0$  to  $3.6$  Vdc,  $V_{SS} = 0$  Vdc,  $T_A = T_L$  to  $T_H$ )

Num	Characteristic	Symbol	Min	Max	Unit
1	Input High Voltage	$V_{IH}$	0.7 ( $V_{DD}$ )	$V_{DD} + 0.3$	V
2	Input Low Voltage	$V_{IL}$	$V_{SS} - 0.3$	0.2 ( $V_{DD}$ )	V
3	Input Hysteresis <sup>1</sup>	$V_{HYS}$	0.5	—	V
4	Input Leakage Current <sup>2</sup> $V_{in} = V_{DD}$ or $V_{SS}$ Input-only pins	$I_{in}$	-2.5	2.5	$\mu$ A
5	High Impedance (Off-State) Leakage Current <sup>2</sup> $V_{in} = V_{DD}$ or $V_{SS}$ All input/output and output pins	$I_{OZ}$	-2.5	2.5	$\mu$ A
6	CMOS Output High Voltage <sup>2, 3</sup> $I_{OH} = -10.0 \mu$ A Group 1, 2, 4 input/output and output pins	$V_{OH}$	$V_{DD} - 0.2$	—	V
7	CMOS Output Low Voltage <sup>2</sup> $I_{OL} = 10.0 \mu$ A Group 1, 2, 4 input/output and output pins	$V_{OL}$	—	0.2	V
8	TTL Compatible Output High Voltage <sup>2, 3</sup> $I_{OH} = -0.4$ mA Group 1, 2, 4 input/output and output pins	$V_{OH}$	$V_{DD} - 0.5$	—	V
9	TTL Compatible Output Low Voltage <sup>2</sup> $I_{OL} = 0.8$ mA Group 1 I/O pins, CLKOUT, FREEZE/QUOT, IPIPE/DSO $I_{OL} = 2.6$ mA Group 2 and Group 4 I/O pins, CSBOOT, BG/CS1 $I_{OL} = 6.0$ mA Group 3	$V_{OL}$	— — —	0.4 0.4 0.4	V
10	Three State Control Input High Voltage	$V_{IHTSC}$	2.4 ( $V_{DD}$ )	9.1	V
11	Data Bus Mode Select Pull-up Current <sup>4</sup> $V_{in} = V_{IL}$ $V_{in} = V_{IH}$	$I_{MSP}$	— -8	-95 —	$\mu$ A
12	$V_{DD}$ Supply Current <sup>5</sup> Run LPSTOP, external clock input frequency = max $f_{sys}$ Run, emulation mode LPSTOP, crystal reference, VCO off (STSIM = 0)	$I_{DD}$	— — — —	56 2 59 350	mA mA mA $\mu$ A
13	Clock Synthesizer Operating Voltage	$V_{DDSYN}$	3.0	3.6	V
14	$V_{DDSYN}$ Supply Current External clock, maximum $f_{sys}$ Crystal reference, VCO on, maximum $f_{sys}$ LPSTOP, crystal reference, VCO off, (STSIM = 0) $V_{DD}$ powered down	$I_{DDSYN}$	— — — —	3 1 150 100	mA mA $\mu$ A $\mu$ A
15	RAM Standby Voltage Specified $V_{DD}$ applied $V_{DD} = V_{SS}$	$V_{SB}$	0.0 2.7	$V_{DD}$ 3.6	V

**Table 5 16.78 MHz DC Characteristics (Continued)**  
 ( $V_{DD}$  and  $V_{DDSYN} = 3.0$  to  $3.6$  Vdc,  $V_{SS} = 0$  Vdc,  $T_A = T_L$  to  $T_H$ )

Num	Characteristic	Symbol	Min	Max	Unit
16	RAM Standby Current <sup>6, 7</sup>	$I_{SB}$	—	10	$\mu A$
	Normal RAM operation $V_{DD} > V_{SB} - 0.5$ V				
	Transient condition $V_{SB} - 0.5$ V $\geq V_{DD} \geq V_{SS} + 0.5$ V				
	Standby operation $V_{DD} < V_{SS} + 0.5$ V			50	$\mu A$
17	Power Dissipation <sup>8</sup>	$P_D$	—	212	mW
18	Input Capacitance <sup>2, 9</sup>	$C_{in}$	—	10	pF
	All input-only pins				
	All input/output pins			20	
19	Load Capacitance <sup>2</sup>	$C_L$	—	90	pF
	Group 1 I/O Pins, CLKOUT, FREEZE/QUOT, $\overline{IPIPE}/DSO$				
	Group 2 I/O Pins and $\overline{CSBOOT}$ , $\overline{BG}/CS1$				
	Group 3 I/O Pins				
	Group 4 I/O Pins			100	

NOTES:

- Applies to:  
QSM pins  
 $\overline{IRQ}[7:1]$ , RESET, EXTAL, TSC, RMC, BKPT/DSCLK, IFETCH/DSI
- Input-Only Pins: TSC, BKPT/DSCLK, RXD  
Output-Only Pins:  $\overline{CSBOOT}$ ,  $\overline{BG}/CS1$ , CLKOUT, FREEZE/QUOT,  $\overline{IPIPE}/DSO$   
Input/Output Pins:  
Group 1: DATA[15:0],  $\overline{IFETCH}/DSI$   
Group 2: ADDR[23:19]/CS[10:6], FC[2:0]/CS[5:3], DSACK[1:0], AVEC, RMC, DS, AS, SIZ[1:0]  
 $\overline{IRQ}[7:1]$ , MODCLK, ADDR[18:0], R/W, BERR, BR/CS0, BGACK/CS2, PCS[3:1], PCS0/SS, TXD  
Group 3: HALT, RESET  
Group 4: MISO, MOSI, SCK
- Does not apply to HALT and RESET because they are open drain pins.  
Does not apply to Port QS[7:0] (TXD, PCS[3:1], PCS0/SS, SCK, MOSI, MISO) in wired-OR mode.
- Current measured at maximum system clock frequency.
- Total operating current is the sum of the appropriate  $V_{DD}$  supply and  $V_{DDSYN}$  supply current.
- When  $V_{SB}$  is more than 0.3V greater than  $V_{DD}$ , current flows between the  $V_{STBY}$  and  $V_{DD}$  pins, which causes standby current to increase toward the maximum condition specification. System noise on the  $V_{DD}$  and  $V_{STBY}$  pin can contribute to this condition.
- The SRAM module will not switch into standby mode as long as  $V_{SB}$  does not exceed  $V_{DD}$  by more than 0.5 volts. The SRAM array cannot be accessed while the module is in standby mode.
- Power dissipation measured at specified system clock frequency, all modules active. Power dissipation can be calculated using the expression:  
$$P_D = 3.6V (I_{DDSYN} + I_{DD})$$
  
 $I_{DD}$  includes supply currents for all device modules powered by  $V_{DD}$  pins
- Input capacitance is periodically sampled rather than 100% tested.



**Table 6 16.78 MHz AC Timing**
 $(V_{DD} \text{ and } V_{DDSYN} = 3.0 \text{ to } 3.6 \text{ Vdc}, V_{SS} = 0 \text{ Vdc}, T_A = T_L \text{ to } T_H^1)$ 

Num	Characteristic	Symbol	Min	Max	Unit
F1	Frequency of Operation	f	DC	16.78	MHz
1	Clock Period	$t_{cyc}$	59.6	—	ns
1A	ECLK Period	$t_{Ecyc}$	476	—	ns
1B	External Clock Input Period <sup>2</sup>	$t_{xcyc}$	59.6	—	ns
2, 3	Clock Pulse Width	$t_{CW}$	24	—	ns
2A, 3A	ECLK Pulse Width	$t_{ECW}$	236	—	ns
2B, 3B	External Clock Input High/Low Time <sup>2</sup>	$t_{xCHL}$	29.8	—	ns
4, 5	CLKOUT Rise and Fall Time	$t_{Crf}$	—	7	ns
4A, 5A	Rise and Fall Time (All outputs except CLKOUT)	$t_{rf}$	—	8	ns
4B, 5B	External Clock Input Rise and Fall Time	$t_{xCrf}$	—	4	ns
6	Clock High to ADDR, FC, $\overline{RMC}$ , SIZ Valid	$t_{CHAV}$	0	29	ns
7	Clock High to ADDR, Data, FC, $\overline{RMC}$ , SIZ High Impedance	$t_{CHAZx}$	0	59	ns
8	Clock High to ADDR, FC, $\overline{RMC}$ , SIZ Invalid	$t_{CHAZn}$	0	—	ns
9	Clock Low to $\overline{AS}$ , $\overline{DS}$ , $\overline{CS}$ Asserted	$t_{CLSA}$	0	25	ns
9A	$\overline{AS}$ to $\overline{DS}$ or $\overline{CS}$ Asserted (Read) <sup>3</sup>	$t_{STSA}$	-15	15	ns
9C	Clock Low to $\overline{IFETCH}$ , $\overline{IPIPE}$ Asserted	$t_{CLIA}$	2	22	ns
11	ADDR, FC, $\overline{RMC}$ , SIZ Valid to $\overline{AS}$ , $\overline{CS}$ , (and $\overline{DS}$ Read) Asserted	$t_{AVSA}$	15	—	ns
12	Clock Low to $\overline{AS}$ , $\overline{DS}$ , $\overline{CS}$ Negated	$t_{CLSN}$	2	29	ns
12A	Clock Low to $\overline{IFETCH}$ , $\overline{IPIPE}$ Negated	$t_{CLIN}$	2	29	ns
13	$\overline{AS}$ , $\overline{DS}$ , $\overline{CS}$ Negated to ADDR, FC, SIZ Invalid (Address Hold)	$t_{SNAI}$	15	—	ns
14	$\overline{AS}$ , $\overline{CS}$ (and $\overline{DS}$ Read) Width Asserted	$t_{SWA}$	100	—	ns
14A	$\overline{DS}$ , $\overline{CS}$ Width Asserted (Write)	$t_{SWAW}$	45	—	ns
14B	$\overline{AS}$ , $\overline{CS}$ (and $\overline{DS}$ Read) Width Asserted (Fast Cycle)	$t_{SWDW}$	40	—	ns
15	$\overline{AS}$ , $\overline{DS}$ , $\overline{CS}$ Width Negated <sup>4</sup>	$t_{SN}$	40	—	ns
16	Clock High to $\overline{AS}$ , $\overline{DS}$ , $R/\overline{W}$ High Impedance	$t_{CHSZ}$	—	59	ns
17	$\overline{AS}$ , $\overline{DS}$ , $\overline{CS}$ Negated to $R/\overline{W}$ High	$t_{SNRN}$	15	—	ns
18	Clock High to $R/\overline{W}$ High	$t_{CHRH}$	0	29	ns
20	Clock High to $R/\overline{W}$ Low	$t_{CHRL}$	0	29	ns
21	$R/\overline{W}$ High to $\overline{AS}$ , $\overline{CS}$ Asserted	$t_{RAAA}$	15	—	ns
22	$R/\overline{W}$ Low to $\overline{DS}$ , $\overline{CS}$ Asserted (Write)	$t_{RASA}$	70	—	ns
23	Clock High to Data Out Valid	$t_{CHDO}$	—	29	ns

**Table 6 16.78 MHz AC Timing (Continued)**
 $(V_{DD} \text{ and } V_{DDSYN} = 3.0 \text{ to } 3.6 \text{ Vdc}, V_{SS} = 0 \text{ Vdc}, T_A = T_L \text{ to } T_H^1)$ 

Num	Characteristic	Symbol	Min	Max	Unit
24	Data Out Valid to Negating Edge of $\overline{AS}$ , $\overline{CS}$ (Fast Write Cycle)	$t_{DVASN}$	15	—	ns
25	$\overline{DS}$ , $\overline{CS}$ Negated to Data Out Invalid (Data Out Hold)	$t_{SNDIO}$	15	—	ns
26	Data Out Valid to $\overline{DS}$ , $\overline{CS}$ Asserted (Write)	$t_{DVSA}$	15	—	ns
27	Data In Valid to Clock Low (Data Setup)	$t_{DICL}$	5	—	ns
27A	Late $\overline{BERR}$ , $\overline{HALT}$ Asserted to Clock Low (Setup Time)	$t_{BELCL}$	20	—	ns
28	$\overline{AS}$ , $\overline{DS}$ Negated to $\overline{DSACK}[1:0]$ , $\overline{BERR}$ , $\overline{HALT}$ , $\overline{AVEC}$ Negated	$t_{SNDN}$	0	80	ns
29	$\overline{DS}$ , $\overline{CS}$ Negated to Data In Invalid (Data In Hold) <sup>5</sup>	$t_{SNDI}$	0	—	ns
29A	$\overline{DS}$ , $\overline{CS}$ Negated to Data In High Impedance <sup>5, 6</sup>	$t_{SHDI}$	—	55	ns
30	CLKOUT Low to Data In Invalid (Fast Cycle Hold) <sup>5</sup>	$t_{CLDI}$	10	—	ns
30A	CLKOUT Low to Data In High Impedance <sup>5</sup>	$t_{CLDH}$	—	90	ns
31	$\overline{DSACK}[1:0]$ Asserted to Data In Valid <sup>7</sup>	$t_{DADI}$	—	50	ns
33	Clock Low to $\overline{BG}$ Asserted/Negated	$t_{CLBAN}$	—	29	ns
35	$\overline{BR}$ Asserted to $\overline{BG}$ Asserted ( $\overline{RMC}$ not Asserted) <sup>8</sup>	$t_{BRAGA}$	1	—	$t_{cyc}$
37	$\overline{BGACK}$ Asserted to $\overline{BG}$ Negated	$t_{GAGN}$	1	2	$t_{cyc}$
39	$\overline{BG}$ Width Negated	$t_{GH}$	2	—	$t_{cyc}$
39A	$\overline{BG}$ Width Asserted	$t_{GA}$	1	—	$t_{cyc}$
46	$R/\overline{W}$ Width Asserted (Write or Read)	$t_{RWA}$	150	—	ns
46A	$R/\overline{W}$ Width Asserted (Fast Write or Read Cycle)	$t_{RWAS}$	90	—	ns
47A	Asynchronous Input Setup Time $\overline{BR}$ , $\overline{BGACK}$ , $\overline{DSACK}[1:0]$ , $\overline{BERR}$ , $\overline{AVEC}$ , $\overline{HALT}$	$t_{AIST}$	5	—	ns
47B	Asynchronous Input Hold Time	$t_{AIHT}$	15	—	ns
48	$\overline{DSACK}[1:0]$ Asserted to $\overline{BERR}$ , $\overline{HALT}$ Asserted <sup>9</sup>	$t_{DABA}$	—	30	ns
53	Data Out Hold from Clock High	$t_{DOCH}$	0	—	ns
54	Clock High to Data Out High Impedance	$t_{CHDH}$	—	28	ns
55	$R/\overline{W}$ Asserted to Data Bus Impedance Change	$t_{RADC}$	40	—	ns
70	Clock Low to Data Bus Driven (Show Cycle)	$t_{SCLDD}$	0	29	ns
71	Data Setup Time to Clock Low (Show Cycle)	$t_{SCLDS}$	15	—	ns
72	Data Hold from Clock Low (Show Cycle)	$t_{SCLDH}$	10	—	ns
73	$\overline{BKPT}$ Input Setup Time	$t_{BKST}$	15	—	ns
74	$\overline{BKPT}$ Input Hold Time	$t_{BKHT}$	10	—	ns
75	Mode Select Setup Time	$t_{MSS}$	20	—	$t_{cyc}$
76	Mode Select Hold Time	$t_{MSH}$	0	—	ns

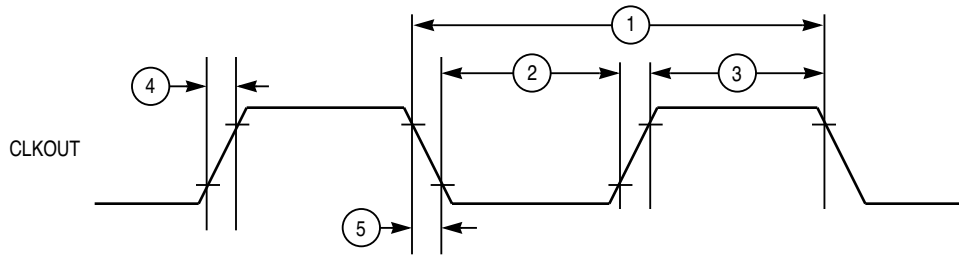
**Table 6 16.78 MHz AC Timing (Continued)**

( $V_{DD}$  and  $V_{DDSYN} = 3.0$  to  $3.6$  Vdc,  $V_{SS} = 0$  Vdc,  $T_A = T_L$  to  $T_H$ )<sup>1</sup>

Num	Characteristic	Symbol	Min	Max	Unit
77	RESET Assertion Time <sup>10</sup>	t <sub>RSTA</sub>	4	—	t <sub>cyc</sub>
78	RESET Rise Time <sup>11, 12</sup>	t <sub>RSTR</sub>	—	10	t <sub>cyc</sub>

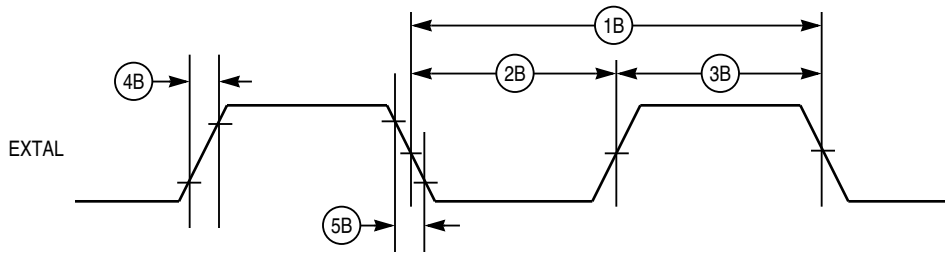
NOTES:

- All AC timing is shown with respect to 2.0 V to 0.8 V levels unless otherwise noted.
- When an external clock is used, minimum high and low times are based on a 50% duty cycle. The minimum allowable t<sub>x<sub>cyc</sub></sub> period is reduced when the duty cycle of the external clock varies. The relationship between external clock input duty cycle and minimum t<sub>x<sub>cyc</sub></sub> is expressed:  
Minimum t<sub>x<sub>cyc</sub></sub> period = minimum t<sub>x<sub>CHL</sub></sub> / (50% – external clock input duty cycle tolerance).
- Specification 9A is the worst-case skew between AS and DS or CS. The amount of skew depends on the relative loading of these signals. When loads are kept within specified limits, skew will not cause AS and DS to fall outside the limits shown in specification 9.
- If multiple chip-selects are used, CS width negated (specification 15) applies to the time from the negation of a heavily loaded chip-select to the assertion of a lightly loaded chip select. The CS width negated specification between multiple chip-selects does not apply to chip selects being used for synchronous ECLK cycles.
- Hold times are specified with respect to DS or CS on asynchronous reads and with respect to CLKOUT on fast cycle reads. The user is free to use either hold time.
- Maximum value is equal to (t<sub>cyc</sub> / 2) + 25 ns.
- If the asynchronous setup time (specification 47A) requirements are satisfied, the DSACK[1:0] low to data setup time (specification 31) and DSACK[1:0] low to BERR low setup time (specification 48) can be ignored. The data must only satisfy the data-in to clock low setup time (specification 27) for the following clock cycle. BERR must satisfy only the late BERR low to clock low setup time (specification 27A) for the following clock cycle.
- To ensure coherency during every operand transfer, BG is not asserted in response to BR until after all cycles of the current operand transfer are complete.
- In the absence of DSACK[1:0], BERR is an asynchronous input using the asynchronous setup time (specification 47A).
- After external RESET negation is detected, a short transition period (approximately 2) t<sub>cyc</sub> elapses, then the SIM drives RESET low for 512 t<sub>cyc</sub>.
- External assertion of the RESET input can overlap internally-generated resets. To insure that an external reset is recognized in all cases, RESET must be asserted for at least 590 CLKOUT cycles.
- External logic must pull RESET high during this period in order for normal MCU operation to begin.



68300 CLKOUT TIM

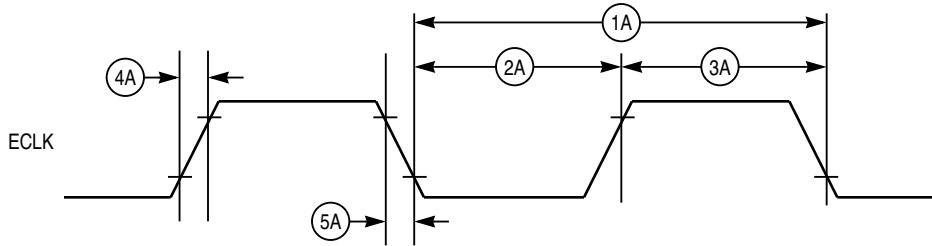
Figure 1 CLKOUT Output Timing Diagram



NOTE: PULSE WIDTH SHOWN WITH RESPECT TO 50%  $V_{DD}$ .

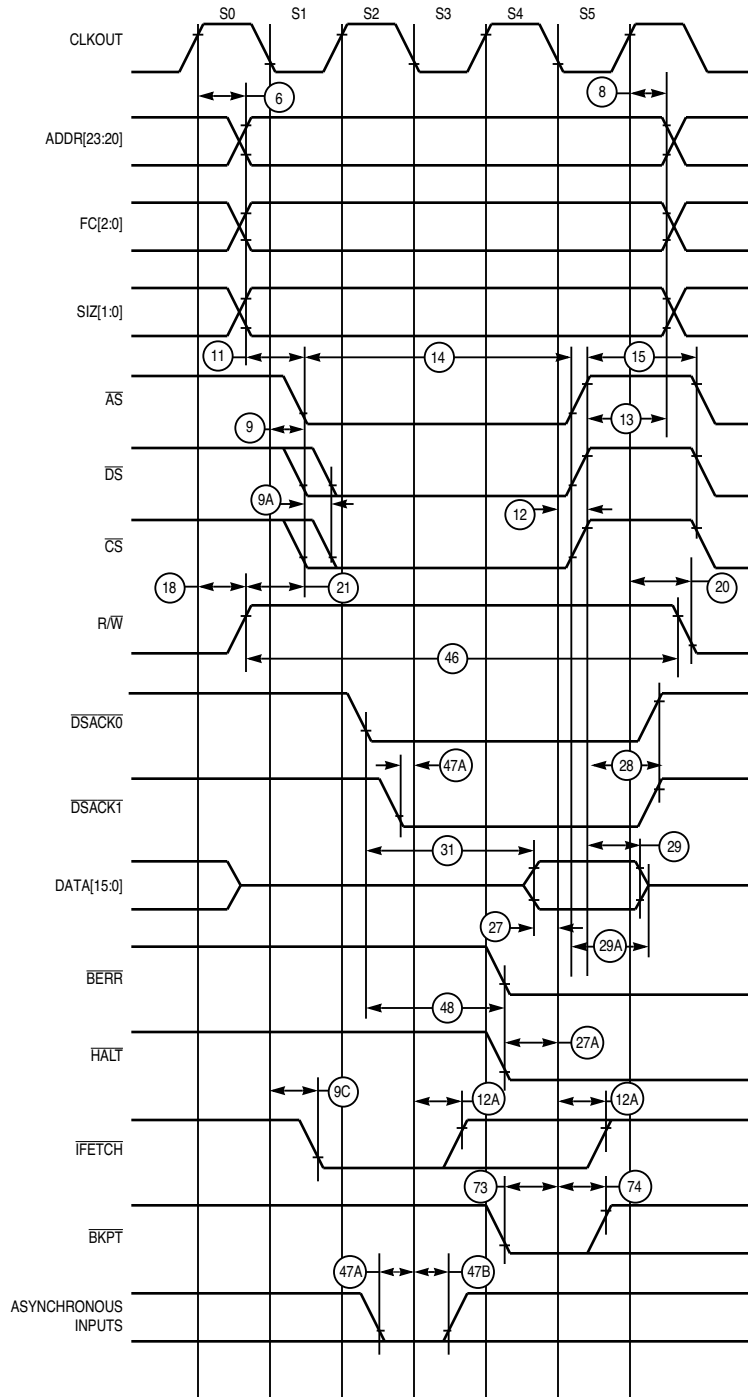
68300 EXT CLK INPUT TIM

Figure 2 External Clock Input Timing Diagram



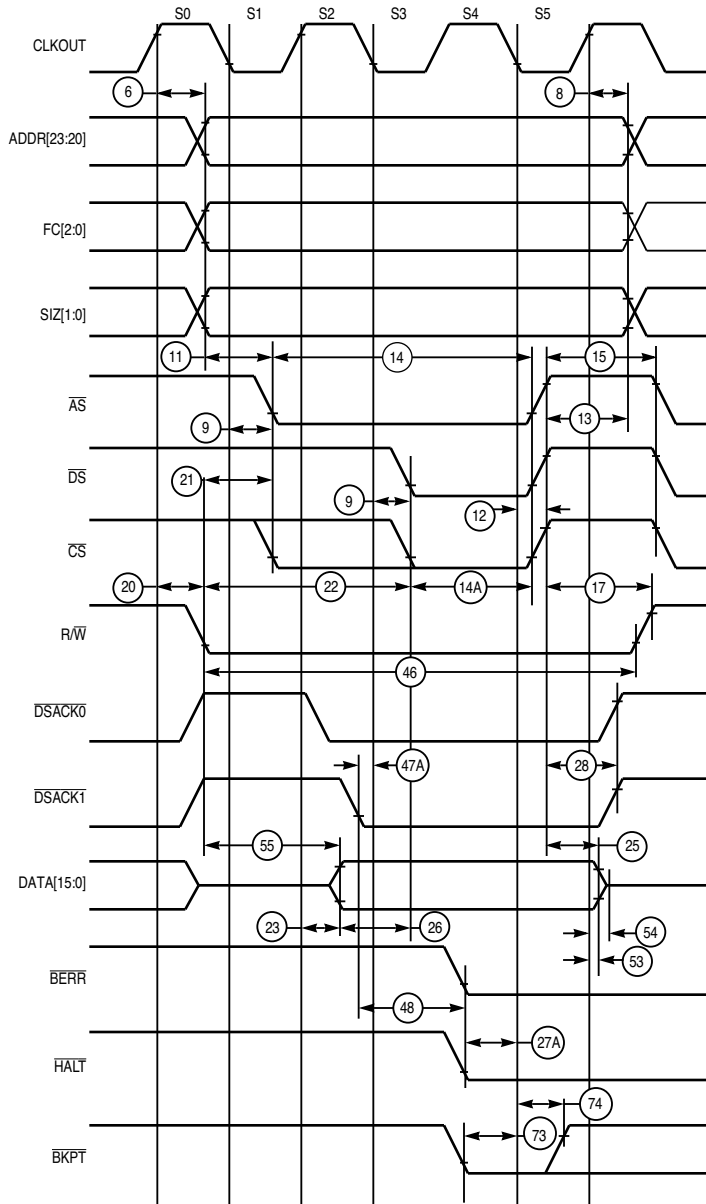
68300 ECLK OUTPUT TIM

Figure 3 ECLK Output Timing Diagram



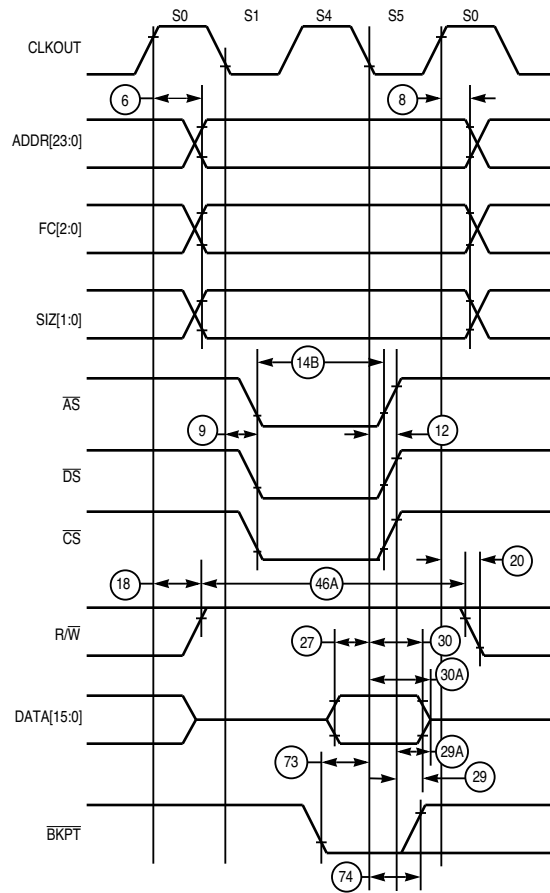
68300 RD CYC TIM

Figure 4 Read Cycle Timing Diagram



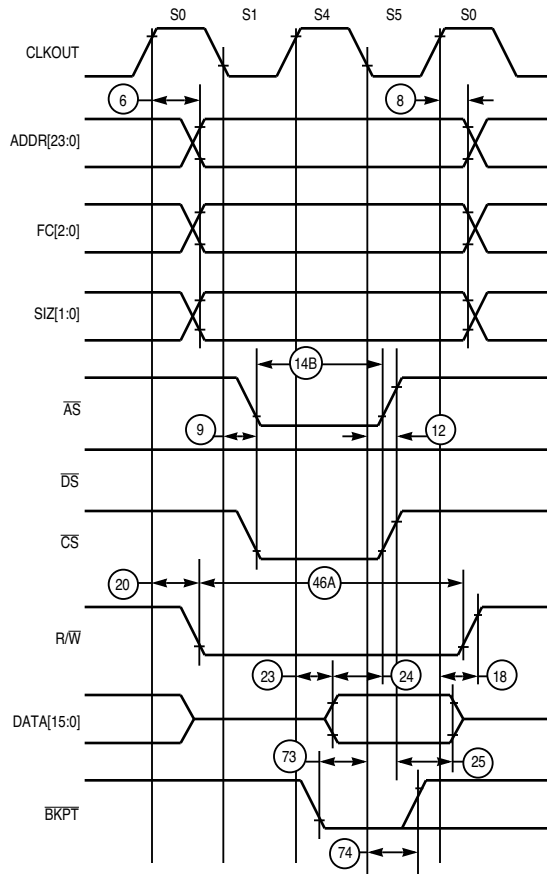
68300 WR CYC TIM

Figure 5 Write Cycle Timing Diagram



68300 FAST RD CYC TIM

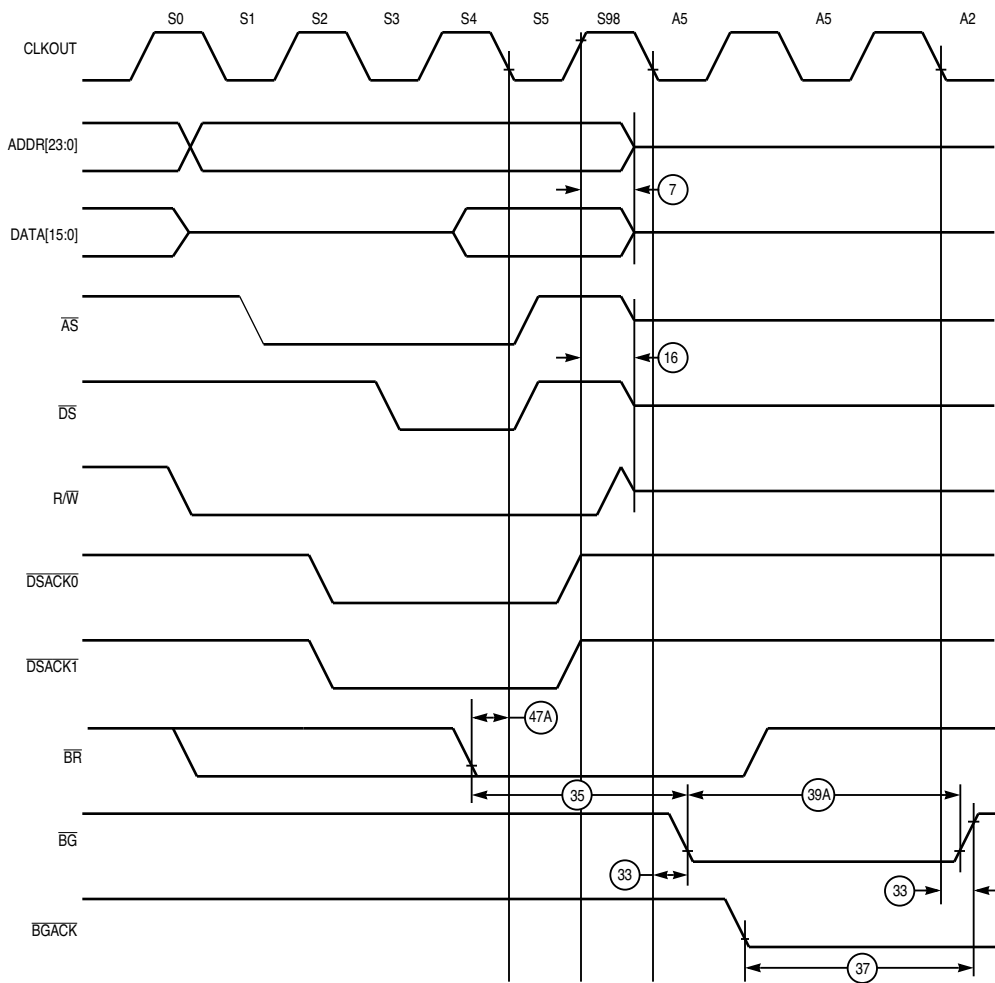
**Figure 6 Fast Termination Read Cycle Timing Diagram**



68300 FAST WR CYC TIM

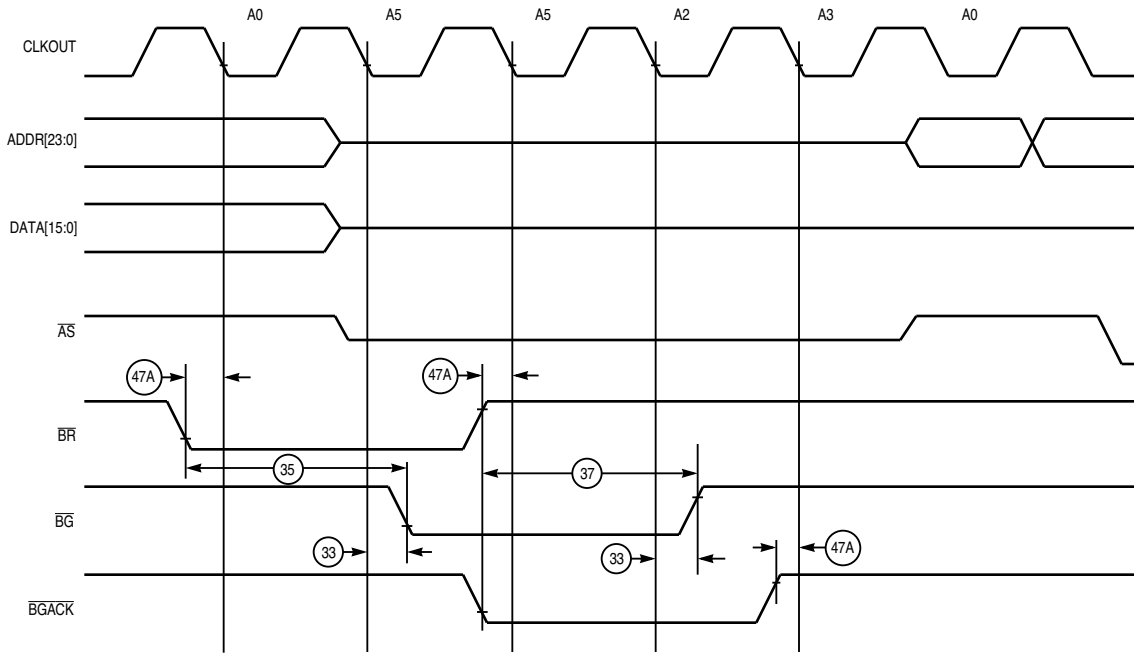
Figure 7 Fast Termination Write Cycle Timing Diagram





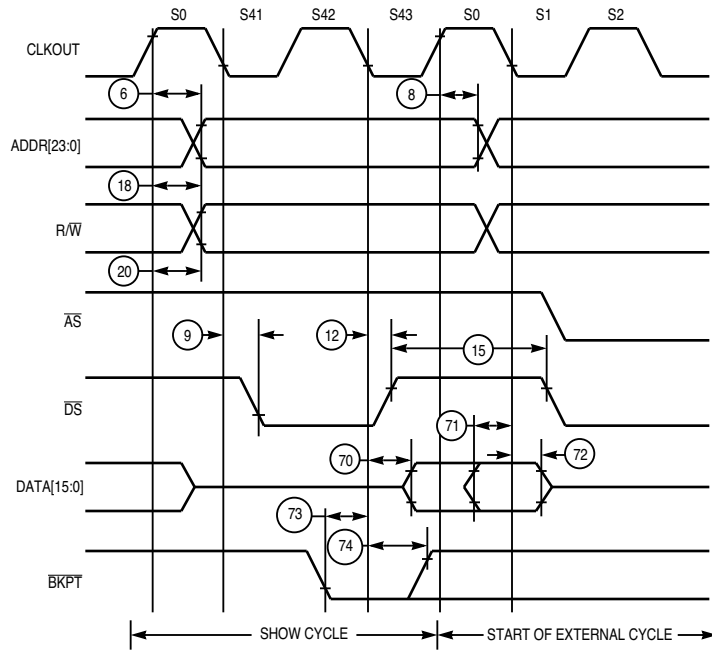
68300 BUS ARB TIM

Figure 8 Bus Arbitration Timing Diagram — Active Bus Case



68300 BUS ARB TIM IDLE

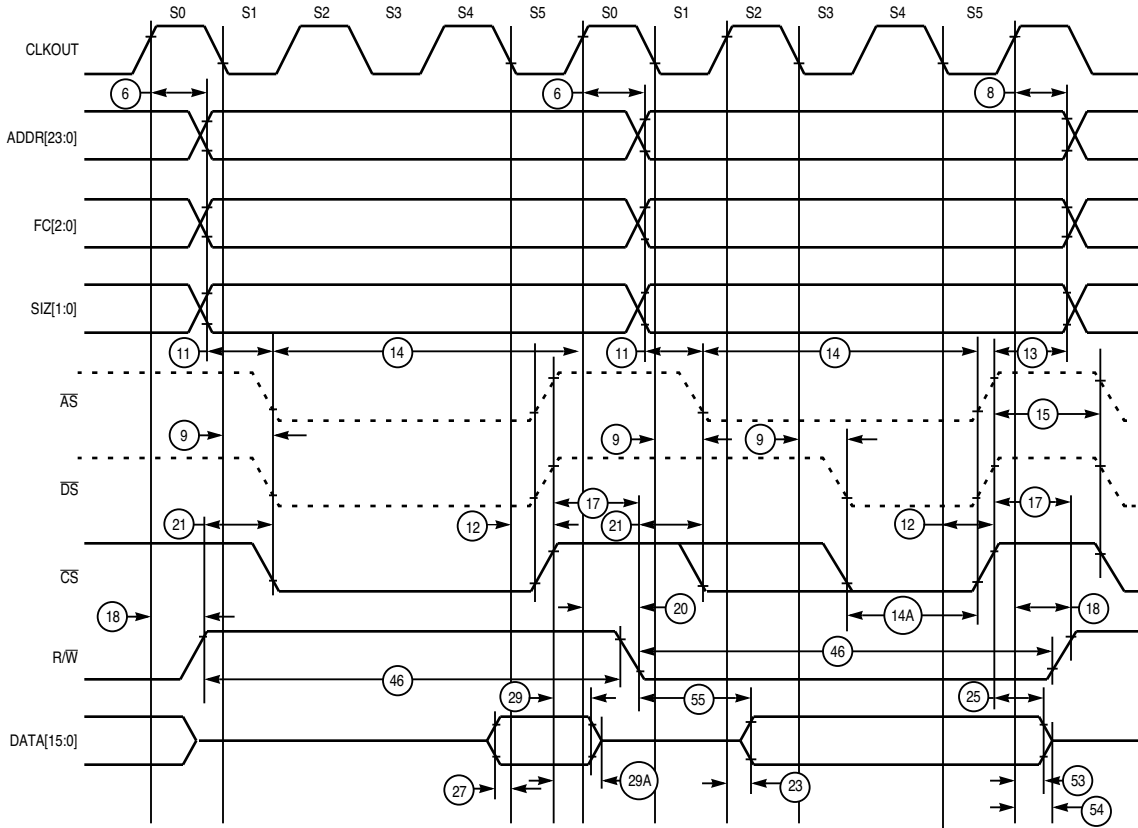
Figure 9 Bus Arbitration Timing Diagram — Idle Bus Case



NOTE:  
 SHOW CYCLES CAN STRETCH DURING CLOCK PHASE S42 WHEN BUS ACCESSES TAKE LONGER THAN TWO CYCLES DUE TO IMB MODULE WAIT-STATE INSERTION.

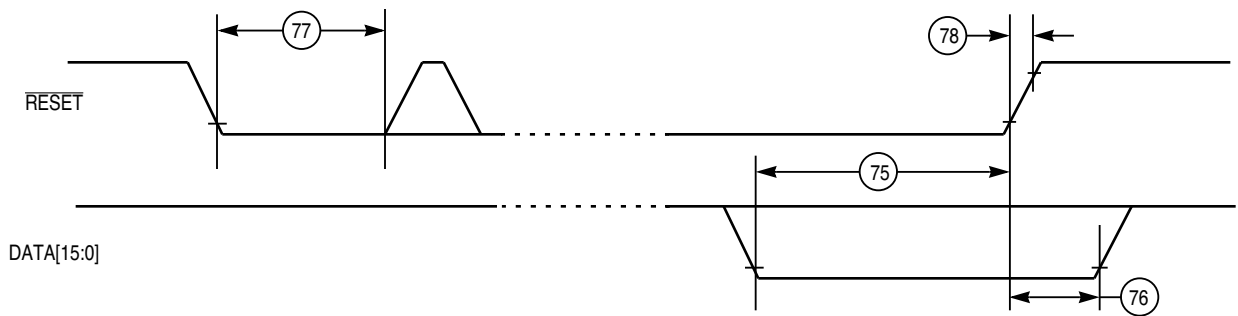
68300 SHW CYC TIM

**Figure 10 Show Cycle Timing Diagram**



68300 CHIP SEL TIM

Figure 11 Chip-Select Timing Diagram



68300 RST/MODE SEL TIM

Figure 12 Reset and Mode Select Timing Diagram

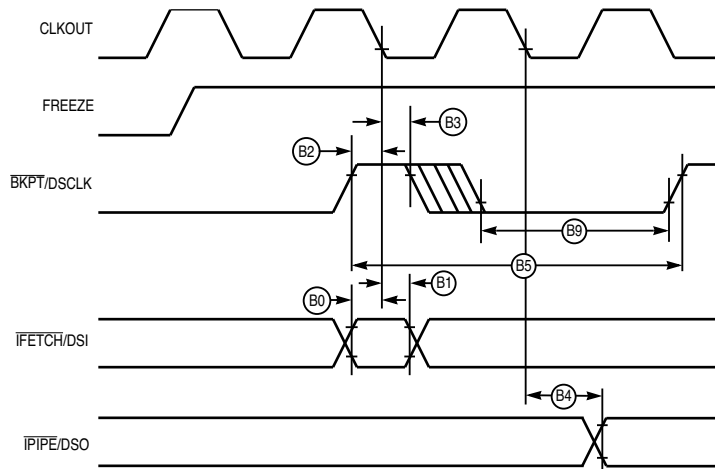
### Table 7 Background Debugging Mode Timing

( $V_{DD}$  and  $V_{DDSYN} = 3.0$  to  $3.6$  Vdc,  $V_{SS} = 0$  Vdc,  $T_A = T_L$  to  $T_H$ )<sup>1</sup>

Num	Characteristic	Symbol	Min	Max	Unit
B0	DSI Input Setup Time	$t_{DSISU}$	15	—	ns
B1	DSI Input Hold Time	$t_{DSIH}$	10	—	ns
B2	DSCLK Setup Time	$t_{DSCSU}$	15	—	ns
B3	DSCLK Hold Time	$t_{DSCCH}$	10	—	ns
B4	DSO Delay Time	$t_{DSOD}$	—	25	ns
B5	DSCLK Cycle Time	$t_{DSCCYC}$	2	—	$t_{cyc}$
B6	CLKOUT Low to FREEZE Asserted/Negated	$t_{FRZAN}$	—	50	ns
B7	CLKOUT High to IFETCH High Impedance	$t_{IPZ}$	—	50	ns
B8	CLKOUT High to IFETCH Valid	$t_{IP}$	—	50	ns
B9	DSCLK Low Time	$t_{DSCLO}$	1	—	$t_{cyc}$

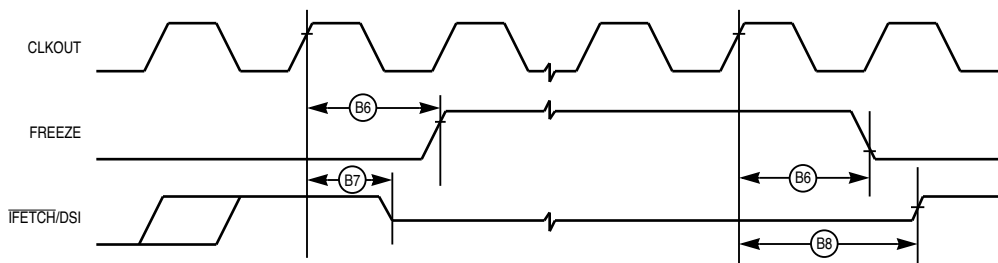
**NOTES:**

1. All AC timing is shown with respect to 20%  $V_{DD}$  and 70%  $V_{DD}$  levels unless otherwise noted.



68300 BKGD DBM SER COM TIM

**Figure 13 BDM Serial Communication Timing Diagram**



68300 BDM FRZ TIM

**Figure 14 BDM Freeze Assertion Timing Diagram**

**Table 8 ECLK Bus Timing**
 $(V_{DD} \text{ and } V_{DDSYN} = 3.0 \text{ to } 3.6 \text{ Vdc, } V_{SS} = 0 \text{ Vdc, } T_A = T_L \text{ to } T_H)^1$ 

Num	Characteristic	Symbol	Min	Max	Unit
E1	ECLK Low to Address Valid <sup>2</sup>	$t_{EAD}$	—	60	ns
E2	ECLK Low to Address Hold	$t_{EAH}$	15	—	ns
E3	ECLK Low to $\overline{CS}$ Valid ( $\overline{CS}$ Delay)	$t_{ECSD}$	—	150	ns
E4	ECLK Low to $\overline{CS}$ Hold	$t_{ECSH}$	15	—	ns
E5	$\overline{CS}$ Negated Width	$t_{ECSN}$	30	—	ns
E6	Read Data Setup Time	$t_{EDSR}$	30	—	ns
E7	Read Data Hold Time	$t_{EDHR}$	5	—	ns
E8	ECLK Low to Data High Impedance	$t_{EDHZ}$	—	60	ns
E9	$\overline{CS}$ Negated to Data Hold (Read)	$t_{ECDH}$	0	—	ns
E10	$\overline{CS}$ Negated to Data High Impedance	$t_{ECDZ}$	—	1	$t_{cyc}$
E11	ECLK Low to Data Valid (Write)	$t_{EDDW}$	—	2	$t_{cyc}$
E12	ECLK Low to Data Hold (Write)	$t_{EDHW}$	15	—	ns
E13	Address Access Time (Read) <sup>3</sup>	$t_{EACC}$	386	—	ns
E14	Chip-Select Access Time (Read) <sup>4</sup>	$t_{EACS}$	296	—	ns
E15	Address Setup Time	$t_{EAS}$	1/2	—	$t_{cyc}$

**NOTES:**

1. All AC timing is shown with respect to 20%  $V_{DD}$  and 70%  $V_{DD}$  levels unless otherwise noted.
2. When previous bus cycle is not an ECLK cycle, the address may be valid before ECLK goes low.
3. Address access time =  $t_{EACC} = t_{EAD} + t_{EDSR}$ .
4. Chip select access time =  $t_{EACS} = t_{ECSD} + t_{EDSR}$ .

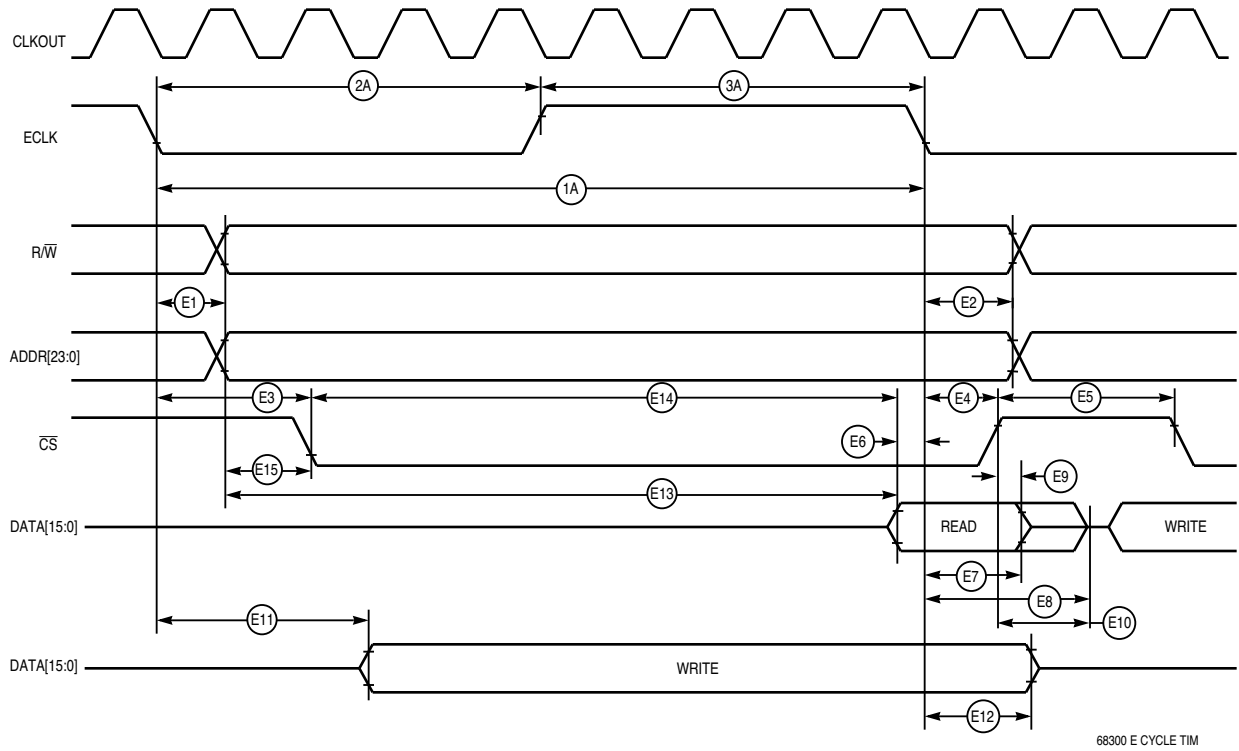


Figure 15 ECLK Timing Diagram

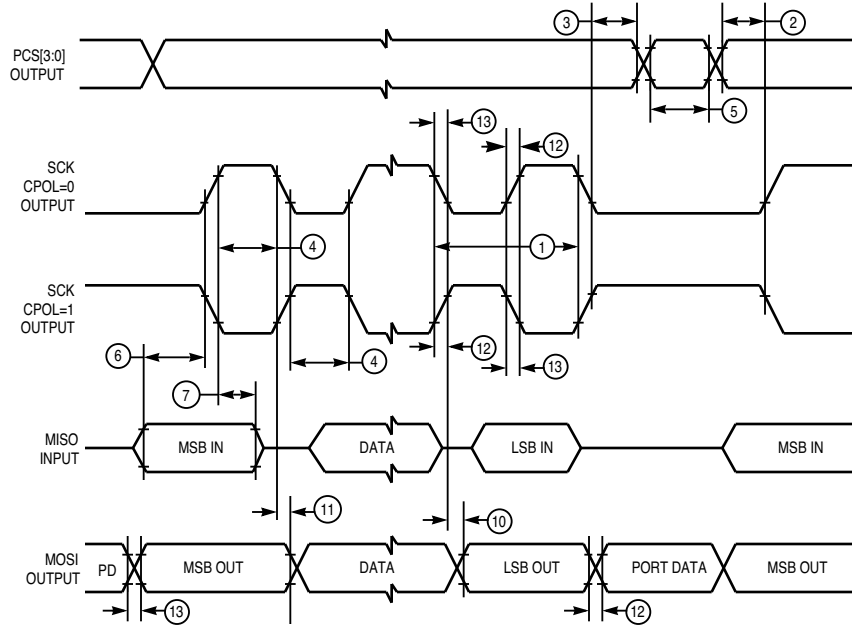
**Table 9 QSPI Timing**
 $(V_{DD}$  and  $V_{DDSYN} = 3.0$  to  $3.6$  Vdc,  $V_{SS} = 0$  Vdc,  $T_A = T_L$  to  $T_H$ ,  $100$  pF load on all QSPI pins)<sup>1</sup>

Num	Function	Symbol	Min	Max	Unit
1	Operating Frequency Master Slave	$f_{op}$	DC	1/4	$f_{sys}$
			DC	1/4	$f_{sys}$
2	Cycle Time Master Slave	$t_{qcyt}$	4	510	$t_{cyc}$
			4	—	$t_{cyc}$
3	Enable Lead Time Master Slave	$t_{lead}$	2	128	$t_{cyc}$
			2	—	$t_{cyc}$
4	Enable Lag Time Master Slave	$t_{lag}$	—	1/2	SCK
			2	—	$t_{cyc}$
5	Clock (SCK) High or Low Time Master Slave <sup>2</sup>	$t_{sw}$	$2 t_{cyc} - 60$	$255 t_{cyc}$	ns
			$2 t_{cyc} - n$	—	ns
6	Sequential Transfer Delay Master Slave (Does Not Require Deselect)	$t_{td}$	17	8192	$t_{cyc}$
			13	—	$t_{cyc}$
7	Data Setup Time (Inputs) Master Slave	$t_{su}$	30	—	ns
			20	—	ns
8	Data Hold Time (Inputs) Master Slave	$t_{hi}$	0	—	ns
			20	—	ns
9	Slave Access Time	$t_a$	—	1	$t_{cyc}$
10	Slave MISO Disable Time	$t_{dis}$	—	2	$t_{cyc}$
11	Data Valid (after SCK Edge) Master Slave	$t_v$	—	50	ns
			—	50	ns
12	Data Hold Time (Outputs) Master Slave	$t_{ho}$	0	—	ns
			0	—	ns
13	Rise Time Input Output	$t_{ri}$ $t_{ro}$	—	2	$\mu$ s
			—	30	ns
14	Fall Time Input Output	$t_{fi}$ $t_{fo}$	—	2	$\mu$ s
			—	30	ns

**NOTES:**

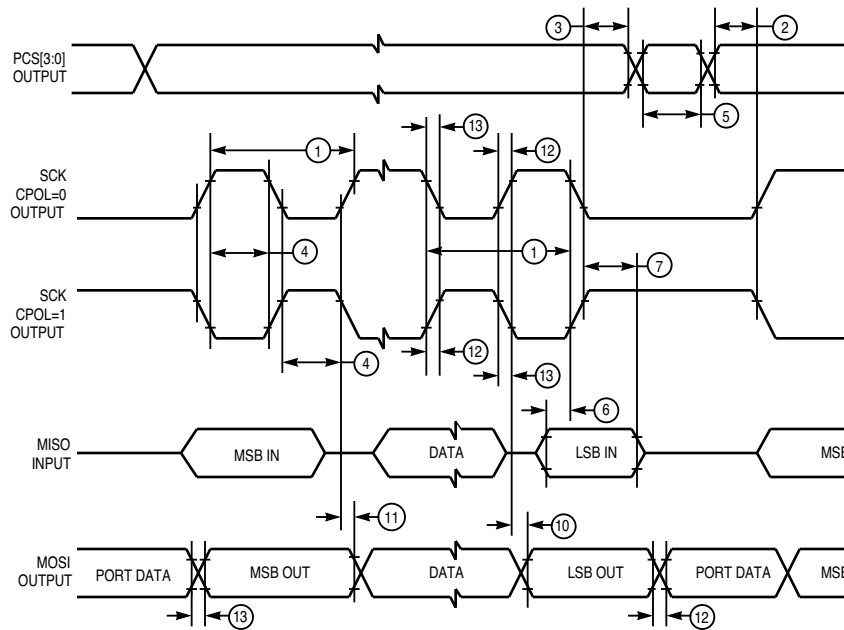
- All AC timing is shown with respect to 20%  $V_{DD}$  and 70%  $V_{DD}$  levels unless otherwise noted.
- For high time,  $n =$  External SCK rise time; for low time,  $n =$  External SCK fall time.





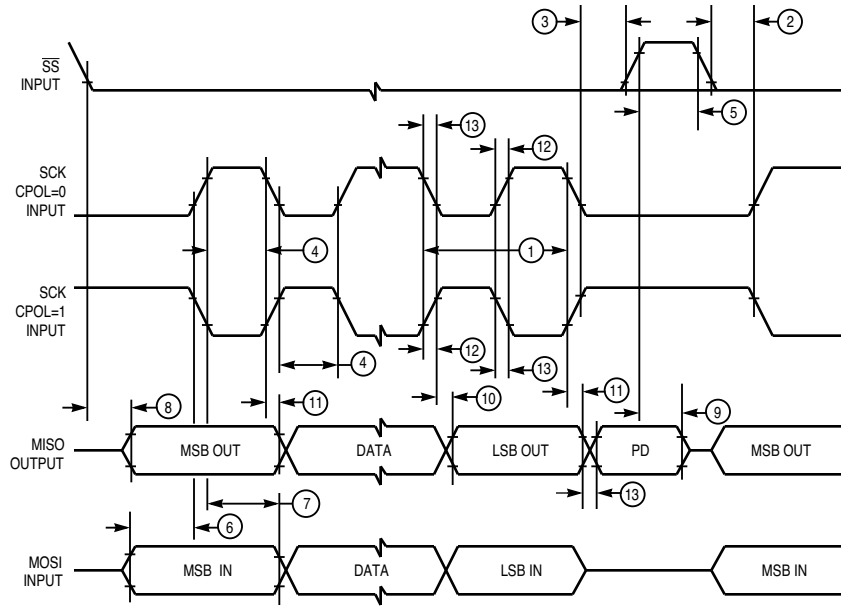
68300 QSPI MAST CPHA0

Figure 16 QSPI Timing — Master, CPHA = 0



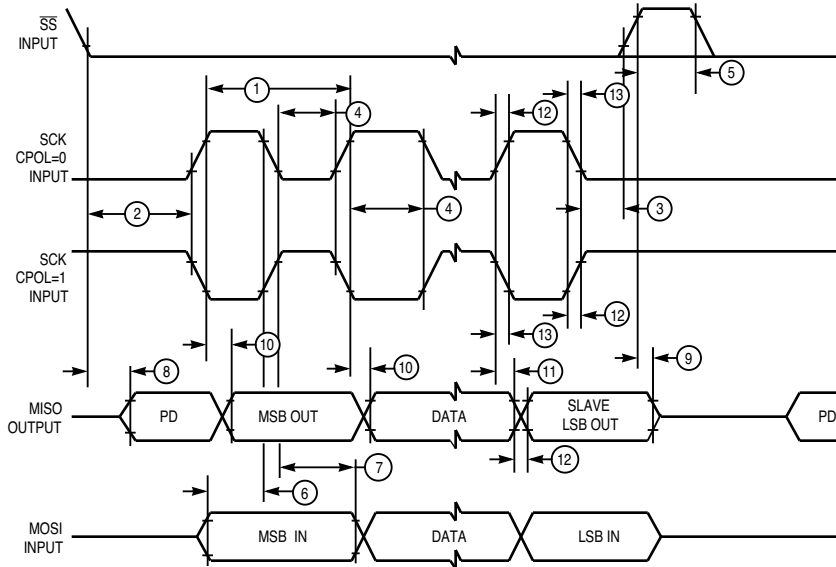
68300 QSPI MAST CPHA1

Figure 17 QSPI Timing — Master, CPHA = 1



68300 QSPI SLV CPHA0

Figure 18 QSPI Timing — Slave, CPHA = 0



68300 QSPI SLV CPHA1

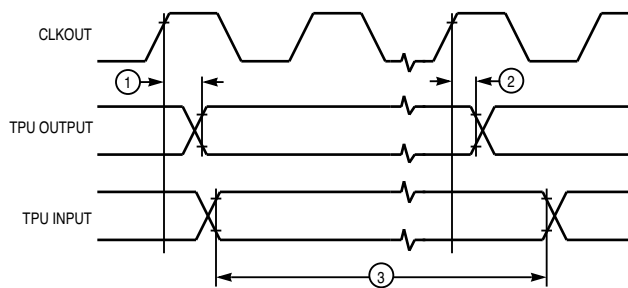
Figure 19 QSPI Timing — Slave, CPHA = 1

**Table 10 Time Processor Unit Timing**  
 ( $V_{DD}$  and  $V_{DDA} = 3.0$  to  $3.6V_{dc}$ ,  $V_{SS} = 0 V_{dc}$ ,  $T_A = T_L$  to  $T_H$ )<sup>1</sup>

Num	Parameter	Symbol	Min	Max	Unit
1	CLKOUT High to TPU Output Channel Valid <sup>2, 3, 4</sup>	$t_{CHTOV}$	2	23	ns
2	CLKOUT High to TPU Output Channel Hold	$t_{CHTOH}$	0	20	ns
3	TPU Input Channel Pulse Width	$t_{TIPW}$	4	—	$t_{cyc}$

**NOTES:**

1. AC Timing is shown with respect to 20%  $V_{DD}$  and 70%  $V_{DD}$  levels.
2. Timing not valid for external T2CLK input.
3. Maximum load capacitance for CLKOUT pin is 90 pF.
4. Maximum load capacitance for TPU output pins is 100 pF.



TPU I/O TIM

**Figure 20 TPU Timing Diagram**



**Home Page:**

[www.freescale.com](http://www.freescale.com)

**email:**

[support@freescale.com](mailto:support@freescale.com)

**USA/Europe or Locations Not Listed:**

Freescale Semiconductor  
Technical Information Center, CH370  
1300 N. Alma School Road  
Chandler, Arizona 85224  
(800) 521-6274  
480-768-2130

[support@freescale.com](mailto:support@freescale.com)

**Europe, Middle East, and Africa:**

Freescale Halbleiter Deutschland GmbH  
Technical Information Center  
Schatzbogen 7  
81829 Muenchen, Germany  
+44 1296 380 456 (English)  
+46 8 52200080 (English)  
+49 89 92103 559 (German)  
+33 1 69 35 48 48 (French)

[support@freescale.com](mailto:support@freescale.com)

**Japan:**

Freescale Semiconductor Japan Ltd.  
Headquarters  
ARCO Tower 15F  
1-8-1, Shimo-Meguro, Meguro-ku  
Tokyo 153-0064, Japan  
0120 191014  
+81 2666 8080

[support.japan@freescale.com](mailto:support.japan@freescale.com)

**Asia/Pacific:**

Freescale Semiconductor Hong Kong Ltd.  
Technical Information Center  
2 Dai King Street  
Tai Po Industrial Estate,  
Tai Po, N.T., Hong Kong  
+800 2666 8080

[support.asia@freescale.com](mailto:support.asia@freescale.com)

**For Literature Requests Only:**

Freescale Semiconductor  
Literature Distribution Center  
P.O. Box 5405  
Denver, Colorado 80217  
(800) 441-2447  
303-675-2140  
Fax: 303-675-2150  
LDCForFreescaleSemiconductor  
[@hibbertgroup.com](mailto:@hibbertgroup.com)

RoHS-compliant and/or Pb- free versions of Freescale products have the functionality and electrical characteristics of their non-RoHS-compliant and/or non-Pb- free counterparts. For further information, see <http://www.freescale.com> or contact your Freescale sales representative.

For information on Freescale's Environmental Products program, go to <http://www.freescale.com/epp>.

Information in this document is provided solely to enable system and software implementers to use Freescale Semiconductor products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document. Freescale Semiconductor reserves the right to make changes without further notice to any products herein. Freescale Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Freescale Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Freescale Semiconductor does not convey any license under its patent rights nor the rights of others. Freescale Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescale Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescale Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold Freescale Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescale Semiconductor was negligent regarding the design or manufacture of the part.



MC68LK332EC16/D

