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MC68331/MC68332

Technical Supplement

25.17 MHz Electrical Characteristics

Devices in the 68300 Modular Microcontroller Family are built up from a selection of standard functional modules. The MC68331 and MC68332 contain the same central processing unit (CPU32) and system integration module (SIM), and thus have similar electrical characteristics.

M68300 devices that operate at clock frequencies of 25.17 MHz are now available. This publication contains new electrical characteristics that supplement the *MC68331 User's Manual* (MC68331UM/AD) and the *MC68332 User's Manual* (MC68332UM/AD).

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Table 1 Maximum Ratings

Num	Rating	Symbol	Value	Unit
1	Supply Voltage[1,2,3]	V_{DD}	– 0.3 to + 6.5	V
2	Input Voltage [1,2,3,4,5,7]	V_{in}	– 0.3 to + 6.5	V
3	Instantaneous Maximum Current Single Pin Limit (all pins)[1,3,5,6]	I_D	25	mA
4	Operating Maximum Current Digital Input Disruptive Current[3,5,6,7,8] $V_{NEGCLMAP} \cong – 0.3$ V $V_{POSCLAMP} \cong V_{DD} + 0.3$	I_{ID}	– 500 to 500	µA
5	Operating Temperature Range C Suffix	T_A	T_L to T_H – 40 to 85	°C
6	Storage Temperature Range	T_{stg}	– 55 to 150	°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 Typical Ratings

Num	Rating	Symbol	Value	Unit
1	Supply Voltage	V_{DD}	5.0	V
2	Operating Temperature	T_A	25	°C
3	V_{DD} Supply Current RUN LPSTOP, VCO off LPSTOP, External clock, max f_{sys}	I_{DD}	 113 125 3.75	 mA µA mA
4	Clock Synthesizer Operating Voltage	V_{DDSYN}	5.0	V
5	V_{DDSYN} Supply Current VCO on, maximum f_{sys} External Clock, maximum f_{sys} LPSTOP, VCO off V_{DD} powered down	I_{DDSYN}	 1.0 5.0 100 50	 mA mA µA µA
6	RAM Standby Current Normal RAM operation Standby operation	I_{SB}	 7.0 40	 µA µA
7	Power Dissipation	P_D	570	mW

Table 3 Thermal Characteristics

Num	Characteristic	Symbol	Value	Unit
1	Thermal Resistance[1] Plastic 132-Pin Surface Mount Plastic 144-pin Surface Mount	Θ_{JA}	 38 49	°C/W

NOTES:

1. The average chip-junction temperature (T_J) in C can be obtained from (1):

$$T_J = T_A + (P_D \cdot \Theta_{JA})$$

where:

T_A= Ambient Temperature, °C

Θ_{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 (2):

$$P_D = K + (T_J + 273°C)$$

Solving equations (1) and (2) for K gives (3):

$$K = P_D + (T_A + 273°C) + \Theta_{JA} \times P_D^2$$

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} and V_{DDSYN} = 5.0 Vdc ± 5%, V_{SS} = 0 Vdc, $T_A = T_L$ to T_H)

Num	Characteristic	Symbol	Minimum	Maximum	Unit
1	PLL Reference Frequency Range	f_{ref}	20	50	kHz
2	System Frequency[1] On-Chip PLL System Frequency External Clock Operation	f_{sys}	dc 4 (f_{ref}) dc	25.17 25.17 25.17	MHz
3	PLL Lock Time[2,4,5,6]	t_{lpll}	—	20	ms
4	VCO Frequency[3]	f_{VCO}	—	2 (f_{sys} max)	MHz
5	Limp Mode Clock Frequency SYNCR X bit = 0 SYNCR X bit = 1	f_{limp}	— —	f_{sys} max /2 f_{sys} max	MHz
6	CLKOUT Jitter[4,5,6,7] Short term (5 μs interval) Long term (500 μs interval)	J_{clk}	–1.0 –0.5	1.0 0.5	%

NOTES:

1. All internal registers retain data at 0 Hz.
2. 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 $\overline{\text{RESET}}$ 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.
3. 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}.
4. This parameter is periodically sampled rather than 100% tested.
5. 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 Ω to guarantee this specification. Filter network geometry can vary depending upon operating environment.
6. Proper layout procedures must be followed to achieve specifications.
7. 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 DC Characteristics

(V_{DD} and V_{DDSYN} = 5.0 Vdc ± 5%, 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[1, 2]	V_{HYS}	0.5	—	V
4	Input Leakage Current[14] V_{in} = V_{DD} or V_{SS}	I_{in}	–2.5	2.5	µA
5	High Impedance (Off-State) Leakage Current[3, 14] V_{in} = V_{DD} or V_{SS}	I_{OZ}	–2.5	2.5	µA
6	CMOS Output High Voltage[4, 5,14] I_{OH} = –10.0 µA	V_{OH}	V_{DD} –0.2	—	V
7	CMOS Output Low Voltage[5,14] I_{OL} = 10.0 µA	V_{OL}	—	0.2	V
8	Output High Voltage[5, 6,14] I_{OH} = –0.8 mA	V_{OH}	V_{DD} –0.8	—	V
9	Output Low Voltage[6,14] I_{OL} = 1.6 mA I_{OL} = 5.3 mA I_{OL} = 12 mA	V_{OL}	— — —	0.4 0.4 0.4	V
10	Three State Control Input High Voltage	V_{IHTSC}	1.6 (V_{DD})	9.1	V
11	Data Bus Mode Select Pull-up Current[7,8] V_{in} = V_{IL} V_{in} = V_{IH}	I_{MSP}	— –15	–120 —	µA
12	V_{DD} Supply Current[9,10] Run (68331) Run (68332) Run, Emulation mode (68332) LPSTOP, crystal reference, VCO Off (STSIM = 0) LPSTOP, external clock input = max f_{sys}	I_{DD}	— — — — —	140 150 160 350 5	mA mA mA µA mA
13	Clock Synthesizer Operating Voltage	V_{DDSYN}	4.75	5.25	V
14	V_{DDSYN} Supply Current[5] VCO on, crystal reference, maximum f_{sys} External Clock, maximum f_{sys} LPSTOP, crystal reference, VCO off (STSIM = 0) V_{DD} powered down	I_{DDSYN}	— — — —	2 6 150 100	mA mA µA µA
15	RAM Standby Voltage Specified V_{DD} applied V_{DD} = V_{SS}	V_{SB}	0.0 3.0	5.25 5.25	V
16	RAM Standby Current[10, 11, 12] Normal RAM operation $V_{DD} > V_{SB} – 0.5$ V Transient condition $V_{SB} – 0.5$ V ≥ V_{DD} ≥ V_{SS} + 0.5 V Standby operation $V_{DD} < V_{SS} + 0.5$ V	I_{SB}	— — —	10 3 50	µA mA µA
17	Power Dissipation[13] (68331) Power Dissipation[13] (68332)	P_D	—	766 819	mW mW

Table 5 DC Characteristics (Continued)

(V_{DD} and V_{DDSYN} = 5.0 Vdc ± 5%, V_{SS} = 0 Vdc, $T_A = T_L$ to T_H)

Num	Characteristic	Symbol	Min	Max	Unit
18	Input Capacitance[14] All input-only pins except ADC pins All input/output pins	C_{in}	— —	10 20	pF
19	Load Capacitance[14] Group 1 I/O Pins, CLKOUT, FREEZE/QUOT, $\overline{IPIPE}$ Group 2 I/O Pins and $\overline{CSBOOT}$, BG/$\overline{CS}$ Group 3 I/O Pins Group 4 I/O Pins	C_L	— — — —	90 100 130 200	pF

NOTES:

1. Applies to:
   Port E[7:4] — SIZ[1:0], $\overline{AS}$, $\overline{DS}$
   Port F[7:0] — $\overline{IRQ}$[7:1], MODCLK
   Port GP[7:0] — IC4/OC5/OC1, IC[3:1], OC[4:1]/OC1
   Port QS[7:0] — TXD, PCS[3:1], PCS0/$\overline{SS}$, SCK, MOSI, MISO
   TPUCH[15:0], T2CLK
   $\overline{BKPT}$/DSCLK, $\overline{IFETCH}$, PAI, PCLK, $\overline{RESET}$, RXD, TSC
   EXTAL (when PLL enabled)
2. This parameter is periodically sampled rather than 100% tested.
3. Applies to all input/output and output pins
4. Does not apply to $\overline{HALT}$ and $\overline{RESET}$ because they are open drain pins. Does not apply to Port QS[7:0] (TXD, PCS[3:1], PCS0/$\overline{SS}$, SCK, MOSI, MISO) in wired-OR mode.
5. Applies to Group 1, 2, 4 input/output and all output pins
6. Applies to Group 1, 2, 3, 4 input/output pins, BG/$\overline{CS}$, CLKOUT, $\overline{CSBOOT}$, FREEZE/QUOT, and $\overline{IPIPE}$
7. Applies to DATA[15:0]
8. Use of an active pulldown device is recommended.
9. Total operating current is the sum of the appropriate I_{DD}, I_{DDSYN}, and I_{SB} values, plus I_{DDA}. I_{DD} values include supply currents for device modules powered by V_{DDE} and V_{DDI} pins.
10. Current measured at maximum system clock frequency, all modules active.
11. When V_{SB} is more than 0.3 V greater than V_{DD}, current flows between the V_{STBY} and V_{DD} pins, which causes standby current to increase toward the maximum transient condition specification. System noise on the V_{DD} and V_{STBY} pin can contribute to this condition.
12. 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.
13. Power dissipation measured at specified system clock frequency, all modules active. Power dissipation can be calculated using the expression:

$$P_D = \text{Maximum } V_{DD} (I_{DD} + I_{DDSYN} + I_{SB})$$

    I_{DD} includes supply currents for all device modules powered by V_{DDE} and V_{DDI} pins.
14. Input-Only Pins: EXTAL, TSC, $\overline{BKPT}$, PAI, PCLK, RXD
    Output-Only Pins: $\overline{CSBOOT}$, BG/$\overline{CS1}$, CLKOUT, FREEZE/QUOT, $\overline{IPIPE}$, PWMA, PWMB
    Input/Output Pins:
    Group 1: Port GP[7:0] — IC4/OC5/OC1, IC[3:1], OC[4:1]/OC1
    DATA[15:0], $\overline{IFETCH}$, TPUCH[15:0]
    Group 2: Port C[6:0] — ADDR[22:19]/$\overline{CS}$[9:6], FC[2:0]/$\overline{CS}$[5:3]
    Port E[7:0] — SIZ[1:0], $\overline{AS}$, $\overline{DS}$, $\overline{AVEC}$, $\overline{DSACK}$[1:0]
    Port F[7:0] — $\overline{IRQ}$[7:1], MODCLK
    Port QS[7:3] — TXD, PCS[3:1], PCS0/$\overline{SS}$
    ADDR23/$\overline{CS10}$/ECLK, ADDR[18:0], R/$\overline{W}$, $\overline{BERR}$, $\overline{BR}$/$\overline{CS0}$, $\overline{BGACK}$/$\overline{CS2}$
    Group 3: $\overline{HALT}$, $\overline{RESET}$
    Group 4: MISO, MOSI, SCK

Table 6 AC Timing

(V_{DD} and V_{DDSYN} = 5.0 Vdc ± 5%, V_{SS} = 0 Vdc, $T_A = T_L$ to T_H)[1]

Num	Characteristic	Symbol	Min	Max	Unit
F1	Frequency of Operation	f	4 (f_{ref})	25.17	MHz
1	Clock Period	t_{cyc}	39.7	—	ns
1A	ECLK Period	t_{Ecyc}	318	—	ns
1B	External Clock Input Period[2]	t_{Xcyc}	39.7	—	ns
2, 3	Clock Pulse Width	t_{CW}	15	—	ns
2A, 3A	ECLK Pulse Width	t_{ECW}	155	—	ns
2B, 3B	External Clock Input High/Low Time[2]	t_{XCHL}	19.8	—	ns
4, 5	CLKOUT Rise and Fall Time	t_{Crf}	—	5	ns
4A, 5A	Rise and Fall Time (All Outputs except CLKOUT)	t_{rf}	—	8	ns
4B, 5B	External Clock Input Rise and Fall Time[3]	t_{XCrf}	—	4	ns
6	Clock High to ADDR, FC, $\overline{RMC}$, SIZ Valid	t_{CHAV}	0	19	ns
7	Clock High to ADDR, Data, FC, $\overline{RMC}$, SIZ High Impedance	t_{CHAZx}	0	39	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	19	ns
9A	$\overline{AS}$ to $\overline{DS}$ or $\overline{CS}$ Asserted (Read)[4]	t_{STSA}	–10	10	ns
9C	Clock Low to $\overline{IFETCH}$, $\overline{IPIPE}$ Asserted	t_{CLIA}	2	19	ns
11	ADDR, FC, $\overline{RMC}$, SIZ Valid to $\overline{AS}$, $\overline{CS}$, (and $\overline{DS}$ Read) Asserted	t_{AVSA}	8	—	ns
12	Clock Low to $\overline{AS}$, $\overline{DS}$, $\overline{CS}$ Negated	t_{CLSN}	2	19	ns
12A	Clock Low to $\overline{IFETCH}$, $\overline{IPIPE}$ Negated	t_{CLIN}	2	19	ns
13	$\overline{AS}$, $\overline{DS}$, $\overline{CS}$ Negated to ADDR, FC, SIZ Invalid (Address Hold)	t_{SNAI}	8	—	ns
14	$\overline{AS}$, $\overline{CS}$ (and $\overline{DS}$ Read) Width Asserted	t_{SWA}	65	—	ns
14A	$\overline{DS}$, $\overline{CS}$ Width Asserted (Write)	t_{SWAW}	25	—	ns
14B	$\overline{AS}$, $\overline{CS}$ (and $\overline{DS}$ Read) Width Asserted (Fast Cycle)	t_{SWDW}	22	—	ns
15	$\overline{AS}$, $\overline{DS}$, $\overline{CS}$ Width Negated[5]	t_{SN}	22	—	ns
16	Clock High to $\overline{AS}$, $\overline{DS}$, R/$\overline{W}$ High Impedance	t_{CHSZ}	—	39	ns
17	$\overline{AS}$, $\overline{DS}$, $\overline{CS}$ Negated to R/$\overline{W}$ High	t_{SNRN}	10	—	ns
18	Clock High to R/$\overline{W}$ High	t_{CHRH}	0	19	ns
20	Clock High to R/$\overline{W}$ Low	t_{CHRL}	0	19	ns
21	R/$\overline{W}$ High to $\overline{AS}$, $\overline{CS}$ Asserted	t_{RAAA}	10	—	ns
22	R/$\overline{W}$ Low to $\overline{DS}$, $\overline{CS}$ Asserted (Write)	t_{RASA}	40	—	ns
23	Clock High to Data Out Valid	t_{CHDO}	—	19	ns
24	Data Out Valid to Negating Edge of $\overline{AS}$, $\overline{CS}$ (Fast Write Cycle)	t_{DVASN}	7	—	ns
25	$\overline{DS}$, $\overline{CS}$ Negated to Data Out Invalid (Data Out Hold)	t_{SNDOI}	5	—	ns
26	Data Out Valid to $\overline{DS}$, $\overline{CS}$ Asserted (Write)	t_{DVSA}	8	—	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}	10	—	ns

Table 6 AC Timing (Continued)

(V_{DD} and V_{DDSYN} = 5.0 Vdc ± 5%, V_{SS} = 0 Vdc, $T_A = T_L$ to T_H)[1]

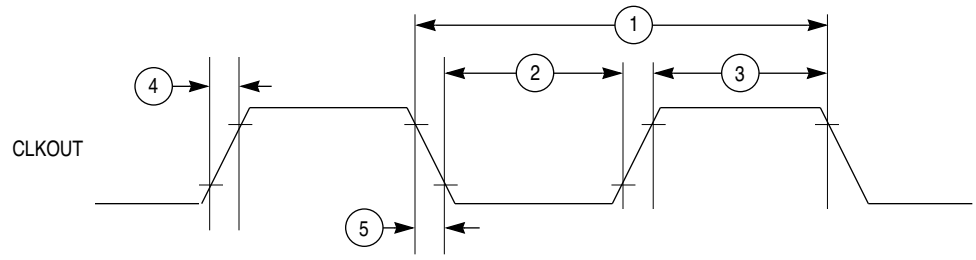
Num	Characteristic	Symbol	Min	Max	Unit
28	$\overline{AS}$, $\overline{DS}$ Negated to $\overline{DSACK}$[1:0], $\overline{BERR}$, $\overline{HALT}$, $\overline{AVEC}$ Negated	t_{SNDN}	0	50	ns
29	$\overline{DS}$, $\overline{CS}$ Negated to Data In Invalid (Data In Hold)[6]	t_{SNDI}	0	—	ns
29A	$\overline{DS}$, $\overline{CS}$ Negated to Data In High Impedance[6, 7]	t_{SHDI}	—	45	ns
30	CLKOUT Low to Data In Invalid (Fast Cycle Hold)[6]	t_{CLDI}	8	—	ns
30A	CLKOUT Low to Data In High Impedance[6]	t_{CLDH}	—	60	ns
31	$\overline{DSACK}$[1:0] Asserted to Data In Valid[8]	t_{DADI}	—	35	ns
33	Clock Low to $\overline{BG}$ Asserted/Negated	t_{CLBAN}	—	19	ns
35	$\overline{BR}$ Asserted to $\overline{BG}$ Asserted ($\overline{RMC}$ not Asserted)[9]	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}	90	—	ns
46A	R/$\overline{W}$ Width Asserted (Fast Write or Read Cycle)	t_{RWAS}	55	—	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}	10	—	ns
48	$\overline{DSACK}$[1:0] Asserted to $\overline{BERR}$, $\overline{HALT}$ Asserted[10]	t_{DABA}	—	27	ns
53	Data Out Hold from Clock High	t_{DOCH}	0	—	ns
54	Clock High to Data Out High Impedance	t_{CHDH}	—	23	ns
55	R/W Asserted to Data Bus Impedance Change	t_{RADC}	25	—	ns
70	Clock Low to Data Bus Driven (Show Cycle)	t_{SCLDD}	0	19	ns
71	Data Setup Time to Clock Low (Show Cycle)	t_{SCLDS}	8	—	ns
72	Data Hold from Clock Low (Show Cycle)	t_{SCLDH}	8	—	ns
73	$\overline{BKPT}$ Input Setup Time	t_{BKST}	10	—	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
77	$\overline{RESET}$ Assertion Time[11]	t_{RSTA}	4	—	t_{cyc}
78	$\overline{RESET}$ Rise Time[12,13]	t_{RSTR}	—	10	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 an external clock is used, minimum high and low times are based on a 50% duty cycle. The minimum allowable t_{Xcyc} period is reduced when the duty cycle of the external clock varies. The relationship between external clock input duty cycle and minimum t_{Xcyc} is expressed:

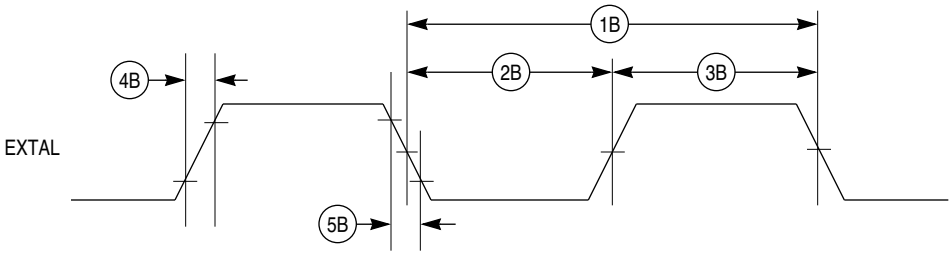
   Minimum t_{Xcyc} period = minimum t_{XCHL} / (50% – external clock input duty cycle tolerance).
3. Parameters for an external clock signal applied while the internal PLL is disabled (MODCLK pin held low during reset). Does not pertain to an external reference applied while the PLL is enabled (MODCLK pin held high during reset). When the PLL is enabled, the clock synthesizer detects successive transitions of the reference signal. If transitions occur within the correct clock period, rise/fall times and duty cycle are not critical.

4. Specification 9A is the worst-case skew between $\overline{AS}$ and $\overline{DS}$ or $\overline{CS}$. The amount of skew depends on the relative loading of these signals. When loads are kept within specified limits, skew will not cause $\overline{AS}$ and $\overline{DS}$ to fall outside the limits shown in specification 9.
5. If multiple chip selects are used, $\overline{CS}$ 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 $\overline{CS}$ width negated specification between multiple chip selects does not apply to chip selects being used for synchronous ECLK cycles.
6. Hold times are specified with respect to $\overline{DS}$ or $\overline{CS}$ on asynchronous reads and with respect to CLKOUT on fast cycle reads. The user is free to use either hold time.
7. Maximum value is equal to (t_{cyc} / 2) + 25 ns.
8. If the asynchronous setup time (specification 47A) requirements are satisfied, the $\overline{DSACK[1:0]}$ low to data setup time (specification 31) and $\overline{DSACK[1:0]}$ low to $\overline{BERR}$ 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. $\overline{BERR}$ must satisfy only the late $\overline{BERR}$ low to clock low setup time (specification 27A) for the following clock cycle.
9. To ensure coherency during every operand transfer, $\overline{BG}$ is not asserted in response to $\overline{BR}$ until after all cycles of the current operand transfer are complete.
10. In the absence of $\overline{DSACK[1:0]}$, $\overline{BERR}$ is an asynchronous input using the asynchronous setup time (specification 47A).
11. After external $\overline{RESET}$ negation is detected, a short transition period (approximately 2) t_{cyc} elapses, then the SIM drives $\overline{RESET}$ low for 512 t_{cyc}.
12. External assertion of the $\overline{RESET}$ input can overlap internally-generated resets. To insure that an external reset is recognized in all cases, $\overline{RESET}$ must be asserted for at least 590 CLKOUT cycles.
13. External logic must pull $\overline{RESET}$ high during this period in order for normal MCU operation to begin.



68300 CLKOUT TIM

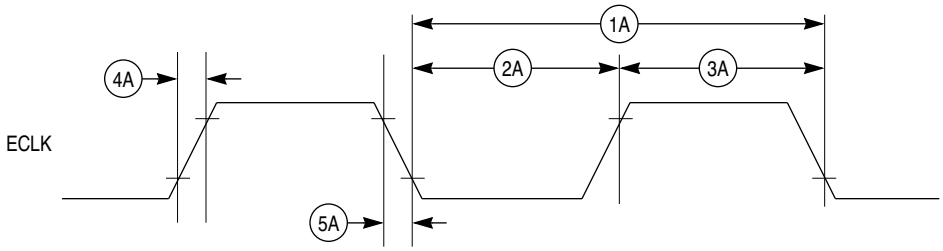
Figure 1 CLKOUT Output Timing Diagram



NOTE: TIMING SHOWN WITH RESPECT TO 20% AND 70% V_{DD}.
PULSE WIDTH SHOWN WITH RESPECT TO 50% V_{DD}.

68300 EXT CLK INPUT TIM

Figure 2 External Clock Input Timing Diagram



NOTE: TIMING SHOWN WITH RESPECT TO 20% AND 70% V_{DD}.

68300 ECLK OUTPUT TIM

Figure 3 ECLK Output Timing Diagram

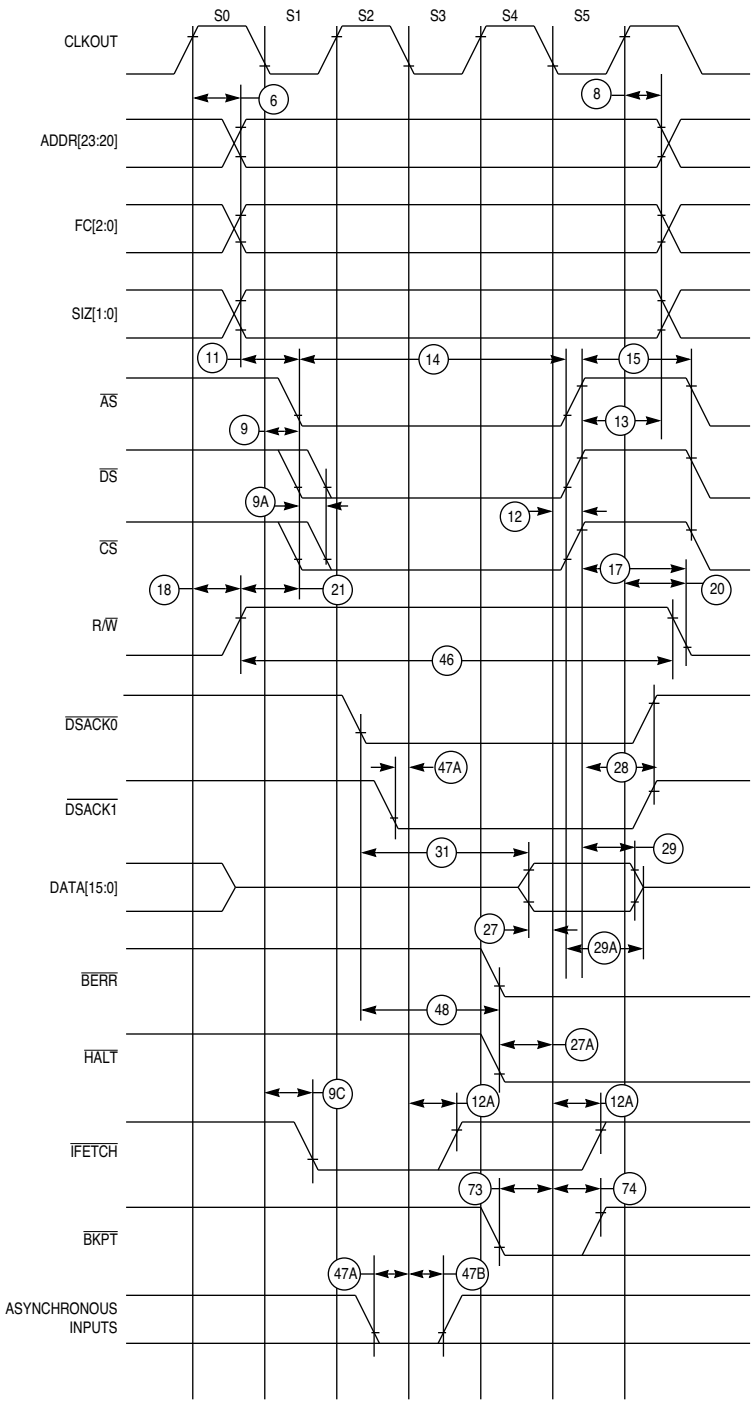
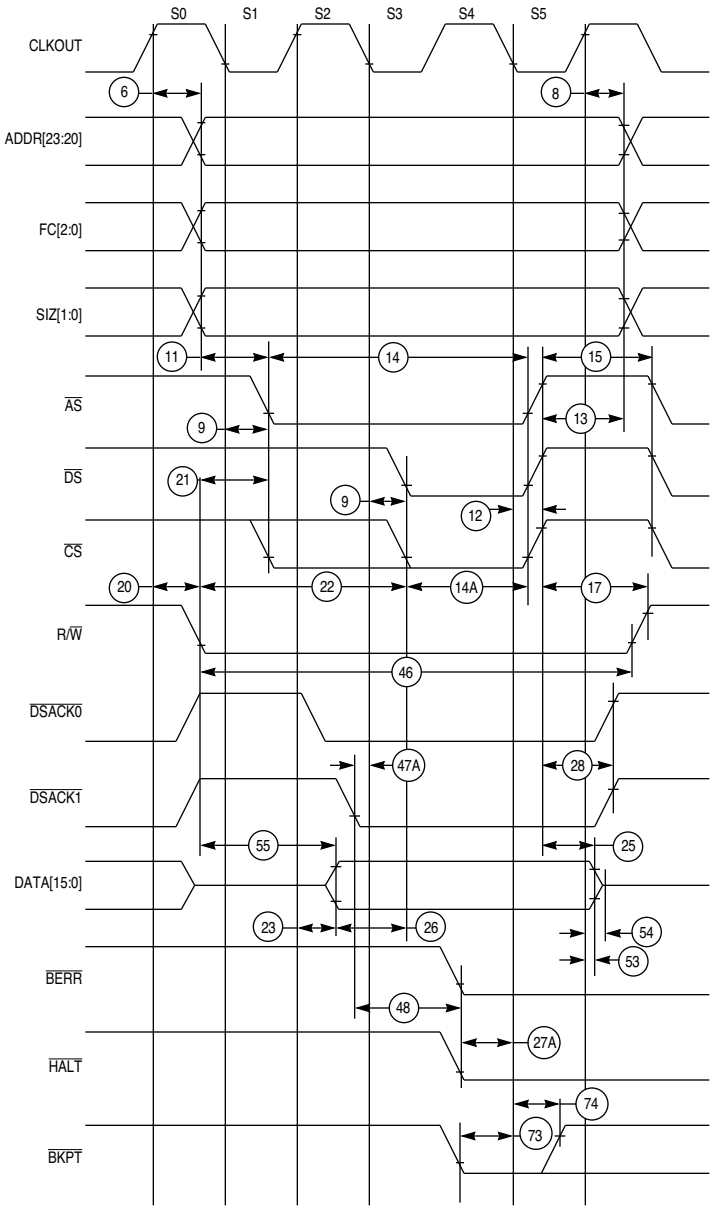


Figure 4 Read Cycle Timing Diagram



68300 WR CYC TIM

Figure 5 Write Cycle Timing Diagram

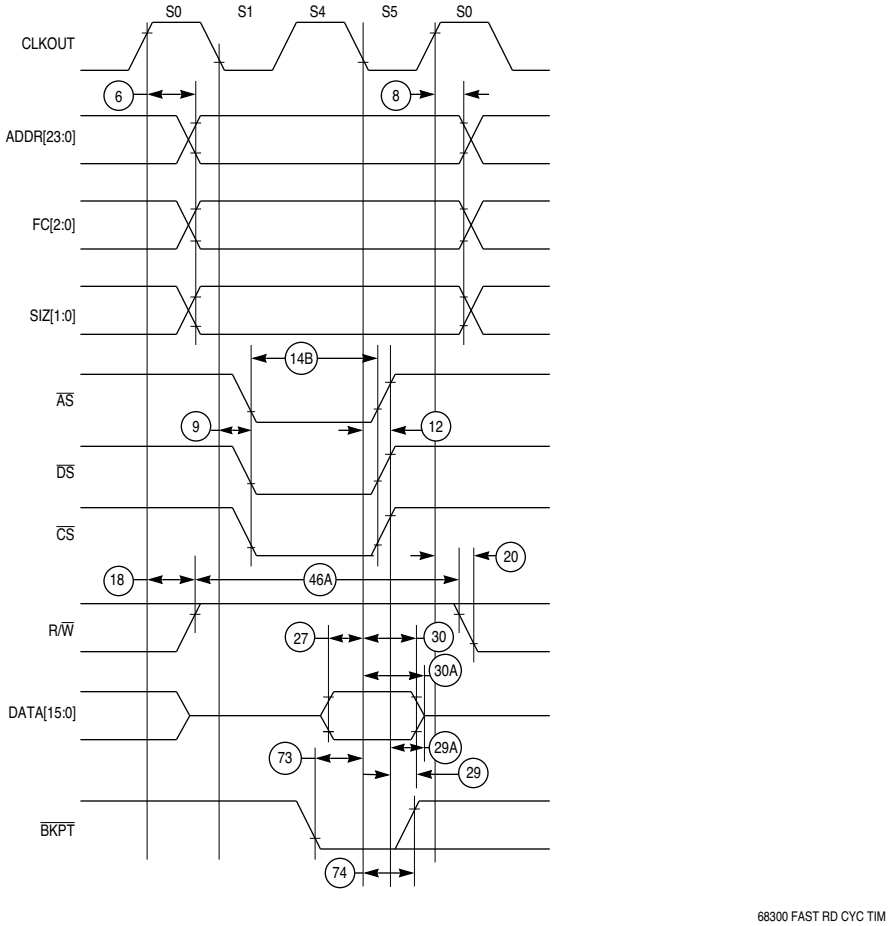


Figure 6 Fast Termination Read Cycle Timing Diagram

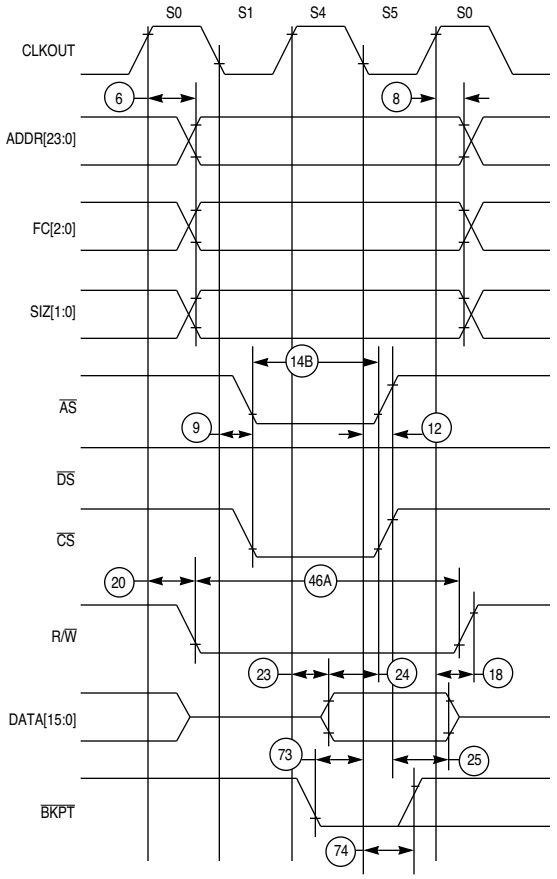


Figure 7 Fast Termination Write Cycle Timing Diagram

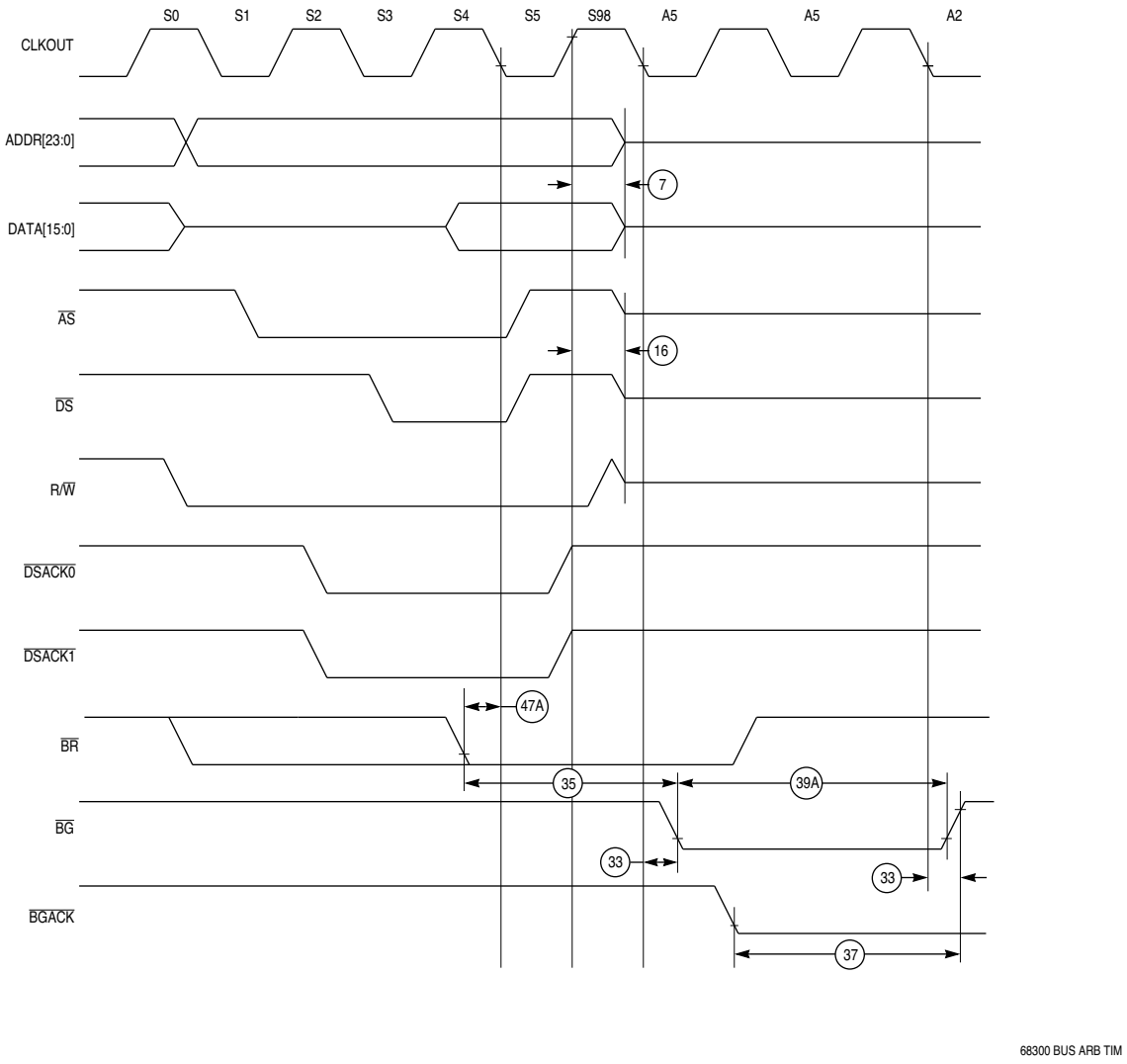
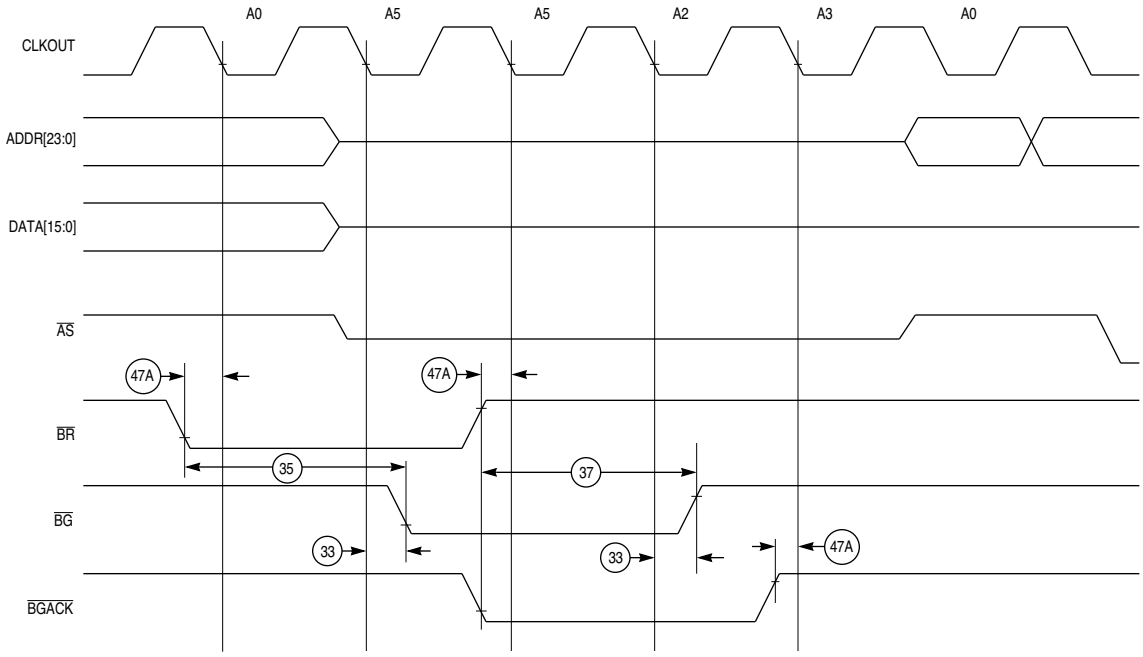
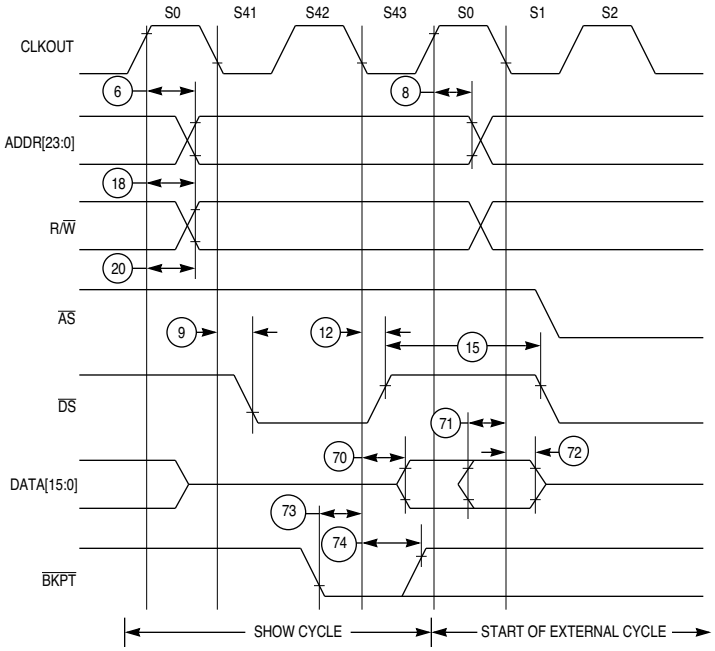


Figure 8 Bus Arbitration Timing Diagram — Active Bus Case



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

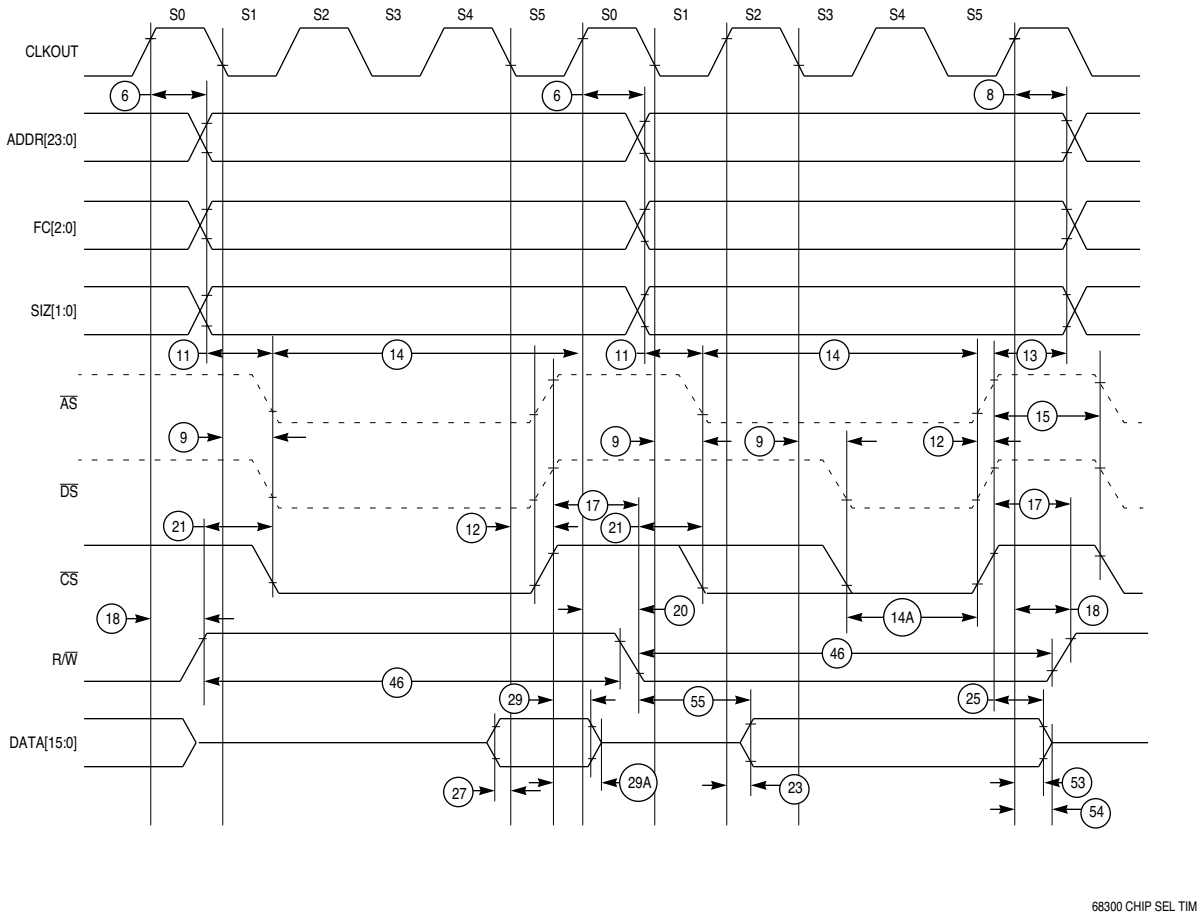


Figure 11 Chip-Select Timing Diagram

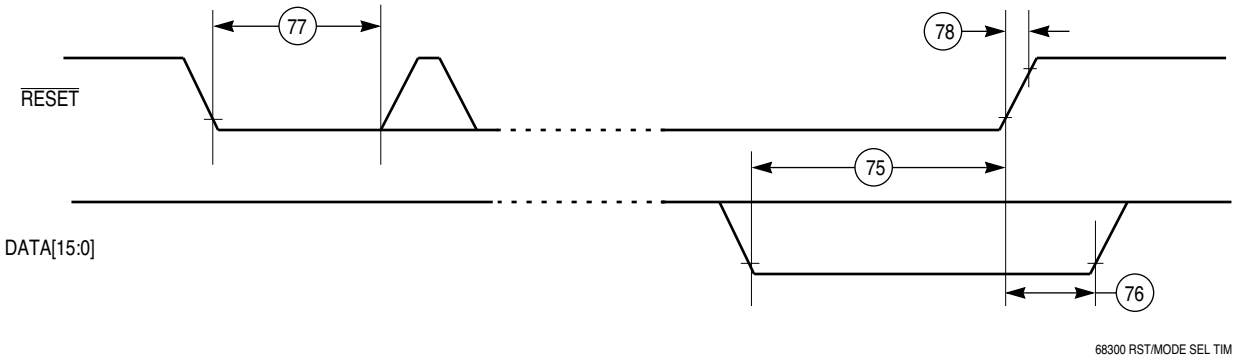


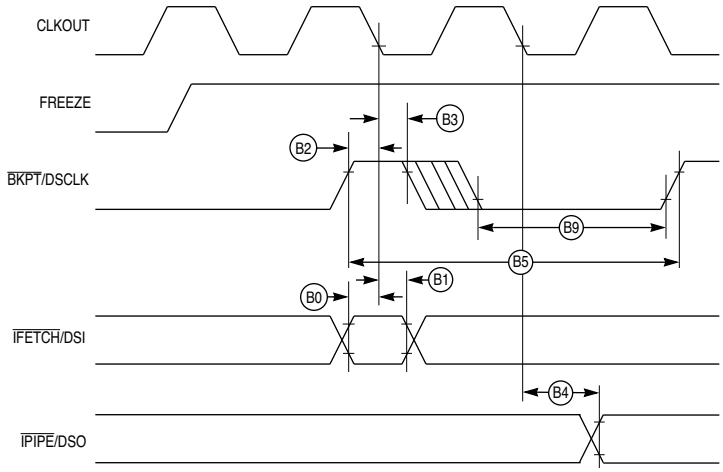
Figure 12 Reset and Mode Select Timing Diagram

Table 7 Background Debugging Mode Timing

(V_{DD} and V_{DDSYN} = 5.0 Vdc ± 5%, V_{SS} = 0 Vdc, $T_A = T_L$ to T_H)[1]

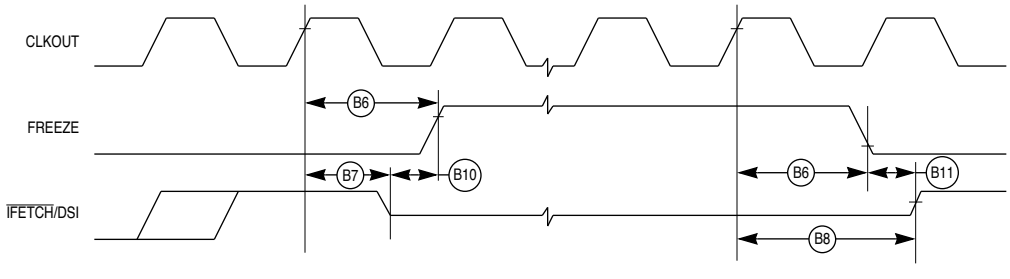
Num	Characteristic	Symbol	Min	Max	Unit
B0	DSI Input Setup Time	t_{DSISU}	10	—	ns
B1	DSI Input Hold Time	t_{DSIH}	5	—	ns
B2	DSCLK Setup Time	t_{DSCSU}	10	—	ns
B3	DSCLK Hold Time	t_{DSCH}	5	—	ns
B4	DSO Delay Time	t_{DSOD}	—	20	ns
B5	DSCLK Cycle Time	t_{DSCCYC}	2	—	t_{cyc}
B6	CLKOUT Low to FREEZE Asserted/Negated	t_{FRZAN}	—	30	ns
B7	CLKOUT High to $\overline{IFETCH}$ High Impedance	t_{IPZ}	—	30	ns
B8	CLKOUT High to $\overline{IFETCH}$ Valid	t_{IP}	—	30	ns
B9	DSCLK Low Time	t_{DSCLO}	1	—	t_{cyc}
B10	$\overline{IFETCH}$ High Impedance to FREEZE Asserted	t_{IZFA}	TBD	—	t_{cyc}
B11	FREEZE Negated to $\overline{IFETCH}$ Active	t_{FNIA}	TBD	—	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} and V_{DDSYN} = 5.0 Vdc ± 5%, V_{SS} = 0 Vdc, $T_A = T_L$ to T_H)[1]

Num	Characteristic	Symbol	Min	Max	Unit
E1	ECLK Low to Address Valid[2]	t_{EAD}	—	40	ns
E2	ECLK Low to Address Hold	t_{EAH}	10	—	ns
E3	ECLK Low to $\overline{CS}$ Valid ($\overline{CS}$ Delay)	t_{ECSD}	—	100	ns
E4	ECLK Low to $\overline{CS}$ Hold	t_{ECSH}	10	—	ns
E5	$\overline{CS}$ Negated Width	t_{ECSN}	20	—	ns
E6	Read Data Setup Time	t_{EDSR}	25	—	ns
E7	Read Data Hold Time	t_{EDHR}	5	—	ns
E8	ECLK Low to Data High Impedance	t_{EDHZ}	—	40	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}	5	—	ns
E13	Address Access Time (Read)[3]	t_{EACC}	255	—	ns
E14	Chip-Select Access Time (Read)[4]	t_{EACS}	195	—	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 = $t_{Ecyc} - t_{EAD} - t_{EDSR}$.
4. Chip select access time = $t_{Ecyc} - t_{ECSD} - t_{EDSR}$.

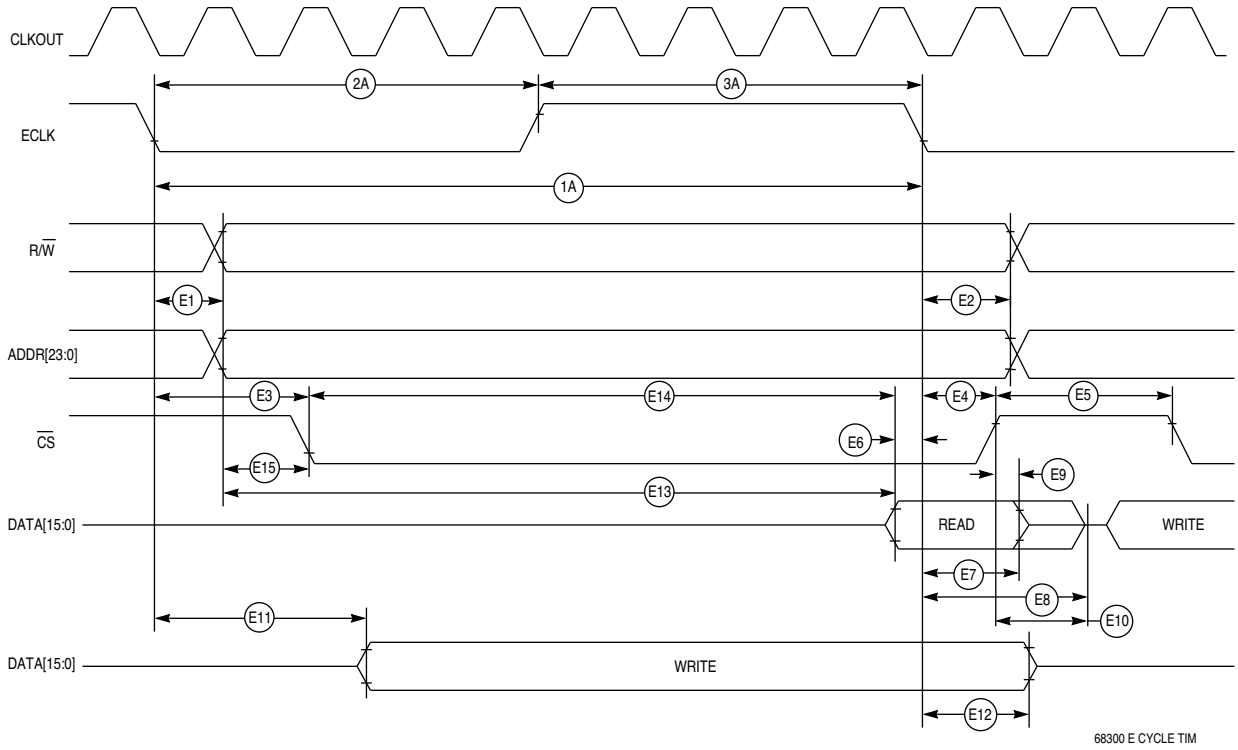


Figure 15 ECLK Timing Diagram

Table 9 QSPI Timing

(V_{DD} and V_{DDSYN} = 5.0 Vdc ± 5%, V_{SS} = 0 Vdc, $T_A = T_L$ to T_H , 200 pF load on all QSPI pins)[1]

Num	Function	Symbol	Min	Max	Unit
1	Operating Frequency Master Slave	f_{op}	DC DC	1/4 1/4	f_{sys} f_{sys}
2	Cycle Time Master Slave	t_{qcyc}	4 4	510 —	t_{cyc} t_{cyc}
3	Enable Lead Time Master Slave	t_{lead}	2 2	128 —	t_{cyc} t_{cyc}
4	Enable Lag Time Master Slave	t_{lag}	— 2	1/2 —	SCK t_{cyc}
5	Clock (SCK) High or Low Time Master Slave[2]	t_{sw}	2 t_{cyc} – 30 2 t_{cyc} – n	255 t_{cyc} —	ns ns
6	Sequential Transfer Delay Master Slave (Does Not Require Deselect)	t_{td}	17 13	8192 —	t_{cyc} t_{cyc}
7	Data Setup Time (Inputs) Master Slave	t_{su}	20 20	— —	ns ns
8	Data Hold Time (Inputs) Master Slave	t_{hi}	0 20	— —	ns 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 50	ns ns
12	Data Hold Time (Outputs) Master Slave	t_{ho}	0 0	— —	ns ns
13	Rise Time Input Output	t_{ri} t_{ro}	— —	2 30	µs ns
14	Fall Time Input Output	t_{fi} t_{fo}	— —	2 30	µs ns

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

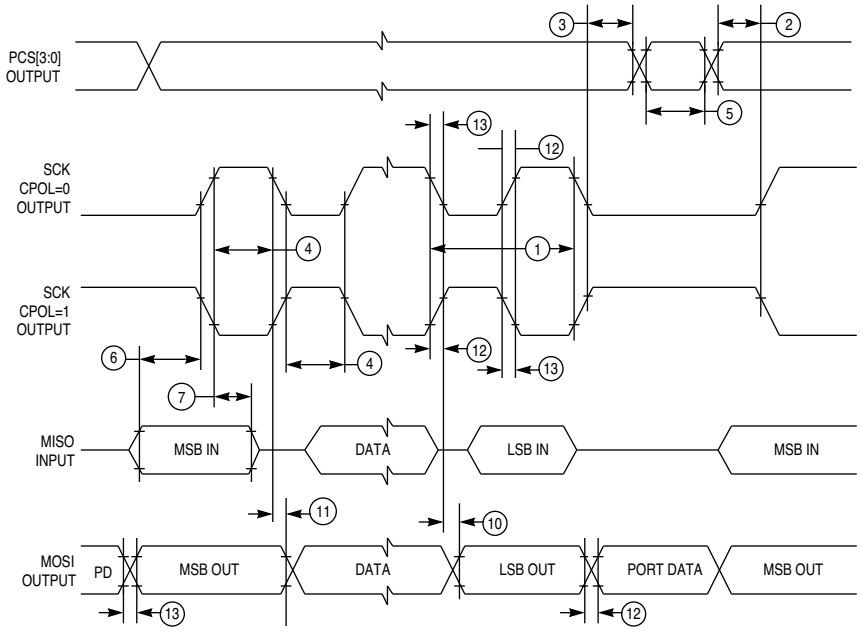


Figure 16 QSPI Timing — Master, CPHA = 0

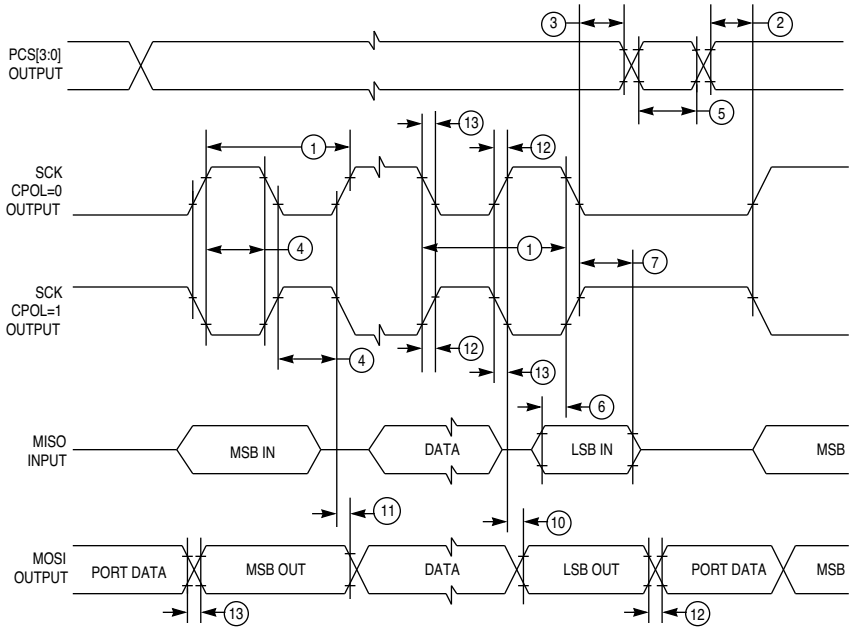
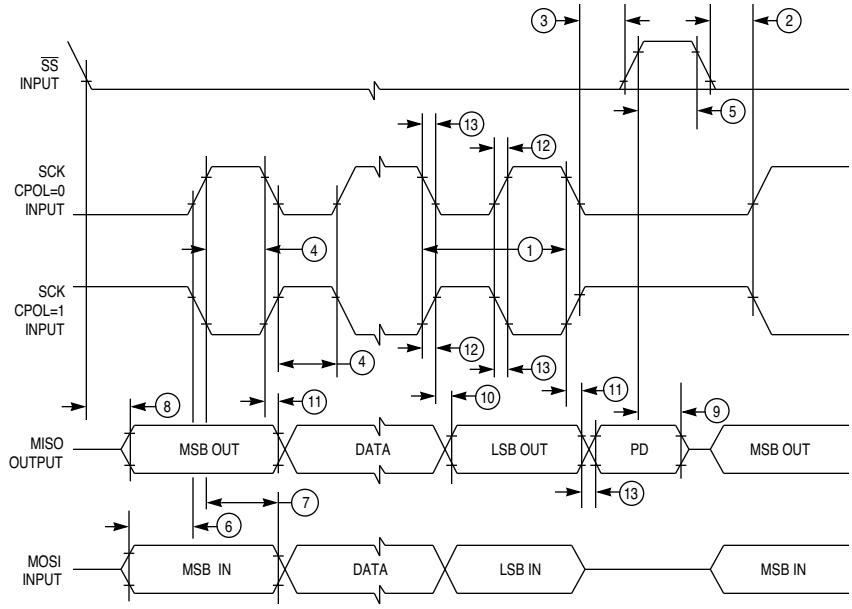
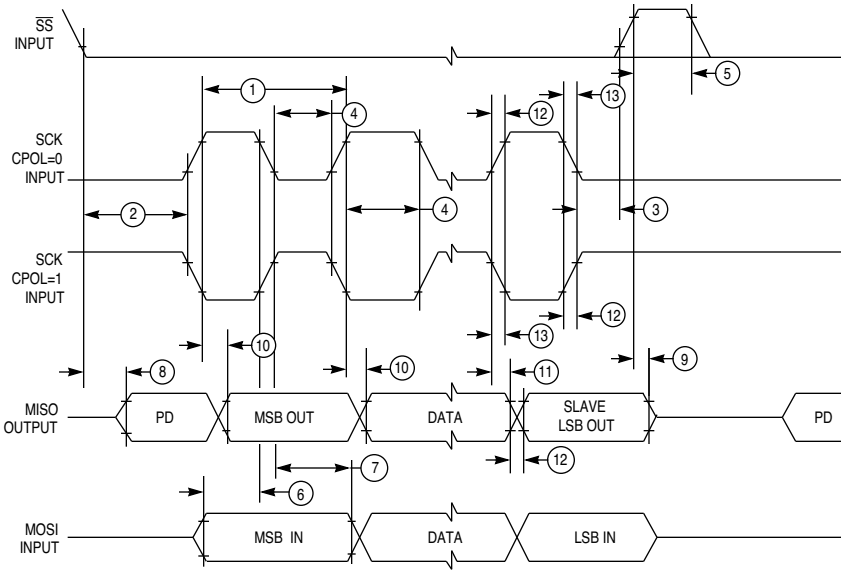


Figure 17 QSPI Timing — Master, CPHA = 1



68300 QSPI SLV CPHA0

Figure 18 QSPI Timing — Slave, CPHA = 0



68300 QSPI SLV CPHA1

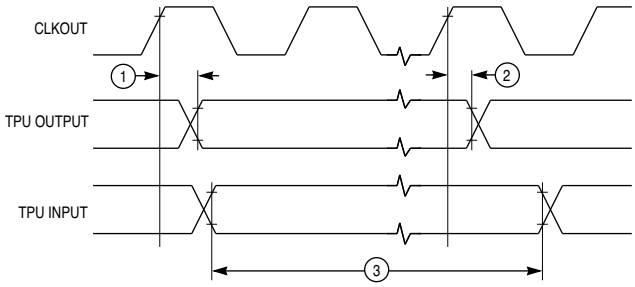
Figure 19 QSPI Timing — Slave, CPHA = 1

Table 10 Time Processor Unit Timing

(V_{DD} and V_{DDA} = 5.0 Vdc ± 5%, V_{SS} = 0 Vdc, $T_A = T_L$ to T_H)[1]

Num	Parameter	Symbol	Min	Max	Unit
1	CLKOUT High to TPU Output Channel Valid[2, 3, 4]	t_{CHTOV}	2	18	ns
2	CLKOUT High to TPU Output Channel Hold	t_{CHTOH}	0	15	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

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