

MC68CK331 **MC68CK331PU**

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 MC68CK331 incorporates a central processing unit (CPU32), a system integration module (SIM), a general-purpose timer (GPT), and a queued serial module (QSM).

This publication contains new electrical characteristics for the MC68CK331/MC68CK331PU to be used in conjunction with the *MC68331 User's Manual* (MC68331UM/AD).

New features on the MC68CK331 include:

- V_{DD} operating range from 2.7 volts to 3.6 volts
- PLL operation at 16.78 MHz
- 5V tolerant, TTL compatible I/O

An additional feature on the MC68CK331PU includes:

- Reduced pin count (100 pin package)

PRELIMINARY



LIST OF FIGURES

Figure		Page
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	Input Signal Conditioner Timing	27
21	Pulse Accumulator —Event Counting Mode (Leading Edge)	28
22	Pulse Accumulator —Gated Mode (Count While Pin High)	29
23	Pulse Accumulator —Using TOF as Gated Mode Clock	30
24	PWMx (PWMx Register = 01, Fast Mode)	30
25	Output Compare (Toggle Pin State)	31
26	Input Capture (Capture on Rising Edge)	32
27	General-Purpose Input	33
28	General-Purpose Output (Causes Input Capture)	34
29	Force Compare (CLEAR)	35
30	MC68CK331 Pin Assignments for 100-Pin Package	36
31	MC68CK331 Pin Assignments for 132-Pin Package	37
32	MC68CK331 Pin Assignments for 144-Pin Package	38

LIST OF TABLES

Table		Page
1	Maximum Ratings	4
2	MC68CK331 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	General-Purpose Timer AC Characteristics	27
11	MC68CK331PU 100-Pin TQFP Pin Assignments	39
12	MC68CK331PU Deleted Function Pin List	39

Table 1 Maximum Ratings

Num	Rating	Symbol	Value	Unit
1	Supply Voltage ^{1, 2, 7}	V_{DD}	–0.3 to + 5.5	V
2	Input Voltage ^{1, 2, 3, 5, 7} TSC	V_{in}	–0.3 to + 5.5 –0.3 to + 6.0	V
3	Instantaneous Maximum Current Single pin limit (applies to all pins) ^{1, 5, 6, 7}	I_D	25	mA
4	Operating Maximum Current Digital Input Disruptive Current ^{4, 5, 6, 7, 8} $V_{NEGCLMAP} \cong -0.3\text{ V}$ $V_{POSCLAMP} \cong V_{DD} + 0.3$	I_{ID}	–500 to 500	μA
5	Operating Temperature Range	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. All pins except TSC.
4. All functional non-supply pins are internally clamped to V_{SS} . All functional pins except EXTAL, TSC, and XFC are internally clamped to V_{DD} .
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 conditions.
7. This parameter is periodically sampled rather than 100% tested.
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 MC68CK331 Typical Ratings

Num	Rating	Symbol	Value	Unit
1	Supply Voltage	V_{DD}	3.0	V
2	Operating Temperature	T_A	25	°C
3	V_{DD} Supply Current RUN LPSTOP, External clock, maximum f_{sys} LPSTOP, VCO off	I_{DD}	35 1.0 70	mA mA μA
4	Clock Synthesizer Operating Voltage	V_{DDSYN}	3.0	V
5	V_{DDSYN} Supply Current External clock, maximum f_{sys} 32.768 kHz Crystal Reference, VCO on, maximum f_{sys}	I_{DDSYN}	1.5 1	mA mA
6	Power Dissipation	P_D	108	mW

Table 3 Thermal Characteristics

Num	Rating	Symbol	Value	Unit
1	Thermal Resistance Plastic 144-Pin Surface Mount Plastic 100-Pin Surface Mount	Θ_{JA}	49 60	°C/W

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
- 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:

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

Solving equations 1 and 2 for K gives:

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

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} and V_{DDSYN} = 2.7 Vdc to 3.6 Vdc, V_{SS} = 0 Vdc, T_A = T_L to T_H, 32.768 kHz reference)

Num	Characteristic	Symbol	Min	Max	Unit
1	PLL Reference Frequency Range	f _{ref}	25	50	kHz
2	System Frequency ¹ On-Chip PLL System Frequency External Clock Operation	f _{sys}	4(f _{ref}) dc	16.78 16.78	MHz
3	PLL Lock Time ^{2,3,4,5}	t _{pll}	—	50	ms
4	VCO Frequency ⁶	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 ^{2, 3, 4, 7} Short term (5 μs interval) Long term (500 μs interval)	J _{clk}	−0.5 −0.05	0.5 0.05	%

NOTES:

1. All internal registers retain data at 0 Hz.
2. This parameter is periodically sampled rather than 100% tested.
3. 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 MΩ to guarantee this specification. Filter network geometry can vary depending upon operating environment.
4. Proper layout procedures must be followed to achieve specifications.
5. 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.
6. 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} ÷ 4. When X = 1, the divider is disabled, and f_{sys} = f_{VCO} ÷ 2. X must equal one when operating at maximum specified f_{sys}.
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 16.78 MHz DC Characteristics

(V_{DD} and $V_{DDSYN} = 2.7$ 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}	2.0	5.5	V
2	Input Low Voltage	V_{IL}	$V_{SS} - 0.3$	0.8	V
3	Input Hysteresis ¹	V_{HYS}	0.5	—	V
4	Input Leakage Current ² $V_{in} = V_{DD}$ or V_{SS} Input-only pins $V_{in} = 5.5$ V	I_{in}	-2.5 -2.5	2.5 2.5	μ A
5	High Impedance (Off-State) Leakage Current ² $V_{in} = V_{DD}$ or V_{SS} All input/output and output pins $V_{in} = 5.5$ V	I_{OZ}	-2.5 -2.5	2.5 2.5	μ A
6	CMOS Output High Voltage ^{2, 3} $I_{OH} = -10.0$ μ A Group 1, 2, 4 input/output and output pins	V_{OH}	$V_{DD} - 0.2$	—	V
7	CMOS Output Low Voltage ² $I_{OL} = 10.0$ μ A Group 1, 2, 4 input/output and output pins	V_{OL}	—	0.2	V
8	TTL Compatible Output High Voltage ^{2, 3} $I_{OH} = -0.4$ mA Group 1, 2, 4 input/output and output pins	V_{OH}	2.4	—	V
9	TTL Compatible Output Low Voltage ² $I_{OL} = 0.8$ mA Group 1 I/O pins, CLKOUT, FREEZE/QUOT, $\overline{IPIPE}$ $I_{OL} = 2.6$ mA Group 2 and Group 4 I/O pins, $\overline{CSBOOT}$, $\overline{BG/CS}$ $I_{OL} = 6$ mA Group 3	V_{OL}	— — —	0.4 0.4 0.4	V
10	Three State Control Input High Voltage	V_{IHTSC}	$1.65 \times V_{DD}$	6.0	V
11	Data Bus Mode Select Pull-up Current ⁴ $V_{in} = V_{IL}$ $V_{in} = V_{IH}$	I_{MSP}	— -8	-95 —	μ A
12	V_{DD} Supply Current ⁵ Run LPSTOP, external clock input frequency = max f_{sys} LPSTOP, VCO off	I_{DD}	— — —	45 2 260	mA mA μ A
13	Clock Synthesizer Operating Voltage	V_{DDSYN}	2.7	3.6	V
14	V_{DDSYN} Supply Current External clock, maximum f_{sys} 32.768 kHz Crystal Reference, VCO on, maximum f_{sys} LPSTOP, 32.768 kHz Crystal Reference, VCO off 32.768 kHz, V_{DD} Powered down	I_{DDSYN}	— —	3 655 150 70	mA μ A μ A μ A
15	Power Dissipation ⁶	P_D	—	173	mW

Table 5 16.78 MHz DC Characteristics (Continued)

(V_{DD} and $V_{DDSYN} = 2.7$ to 3.6 Vdc, $V_{SS} = 0$ Vdc, $T_A = T_L$ to T_H)

Num	Characteristic	Symbol	Min	Max	Unit
16	Input Capacitance ^{2, 7} All input-only pins All input/output pins	C_{in}	— —	10 20	pF
17	Load Capacitance ² Group 1 I/O Pins, CLKOUT, FREEZE/QUOT, $\overline{IPIPE}$ Group 2 I/O Pins and $\overline{CSBOOT}$, $\overline{BG/CS}$ Group 3 I/O Pins Group 4 I/O Pins	C_L	— — — —	80 80 80 80	pF

NOTES:

- Applies to:
QSM pins
 $\overline{IRQ[7:1]}$, $\overline{RESET}$, $\overline{EXTAL}$, $\overline{TSC}$, $\overline{RMC}$, $\overline{BKPT/DSCLK}$, $\overline{IFETCH/DSI}$
- Input-Only Pins: $\overline{TSC}$, $\overline{BKPT/DSCLK}$, $\overline{RXD}$
Output-Only Pins: $\overline{CSBOOT}$, $\overline{BG/CS}$, $\overline{CLKOUT}$, $\overline{FREEZE/QUOT}$, $\overline{IPIPE/DSO}$
Input/Output Pins:
Group 1: $\overline{DATA[15:0]}$, $\overline{IFETCH/DSI}$
Group 2: $\overline{ADDR[23:19]/CS[10:6]}$, $\overline{FC[2:0]/CS[5:3]}$, $\overline{DSACK[1:0]}$, $\overline{AVEC}$, $\overline{RMC}$, $\overline{DS}$, $\overline{AS}$, $\overline{SIZ[1:0]}$
 $\overline{IRQ[7:1]}$, $\overline{MODCLK}$, $\overline{ADDR[18:0]}$, $\overline{R/W}$, $\overline{BERR}$, $\overline{BR/CS0}$, $\overline{BGACK/CS2}$, $\overline{PCS[3:1]}$, $\overline{PCS0/SS}$, $\overline{TXD}$
Group 3: $\overline{HALT}$, $\overline{RESET}$
Group 4: $\overline{MISO}$, $\overline{MOSI}$, $\overline{SCK}$
- Does not apply to $\overline{HALT}$ and $\overline{RESET}$ because they are open drain pins.
Does not apply to Port QS[7:0] ($\overline{TXD}$, $\overline{PCS[3:1]}$, $\overline{PCS0/SS}$, $\overline{SCK}$, $\overline{MOSI}$, $\overline{MISO}$) 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.
- 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_{DDE} and V_{DDI} pins.
- Input capacitance is periodically sampled rather than 100% tested.

Table 6 16.78 MHz AC Timing

$$(V_{DD} \text{ and } V_{DDSYN} = 2.7 \text{ to } 3.6 \text{ Vdc}, V_{SS} = 0 \text{ Vdc}, T_A = T_L \text{ to } T_H)^1$$

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 ²	t _{x_{cyc}}	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 ²	t _{x_{CHL}}	29.8	—	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	t _{x_{Crf}}	—	5	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}	2	25	ns
9A	$\overline{AS}$ to $\overline{DS}$ or $\overline{CS}$ Asserted (Read) ³	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	22	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 ⁴	t _{SN}	40	—	ns
16	Clock High to $\overline{AS}$, $\overline{DS}$, R/W High Impedance	t _{CHSZ}	—	59	ns
17	$\overline{AS}$, $\overline{DS}$, $\overline{CS}$ Negated to R/W High	t _{SNRN}	15	—	ns
18	Clock High to R/W High	t _{CHRH}	0	29	ns
20	Clock High to R/W Low	t _{CHRL}	0	29	ns
21	R/W High to $\overline{AS}$, $\overline{CS}$ Asserted	t _{RAAA}	15	—	ns
22	R/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} and $V_{DDSYN} = 2.7$ to 3.6 Vdc, $V_{SS} = 0$ Vdc, $T_A = T_L$ to T_H)¹

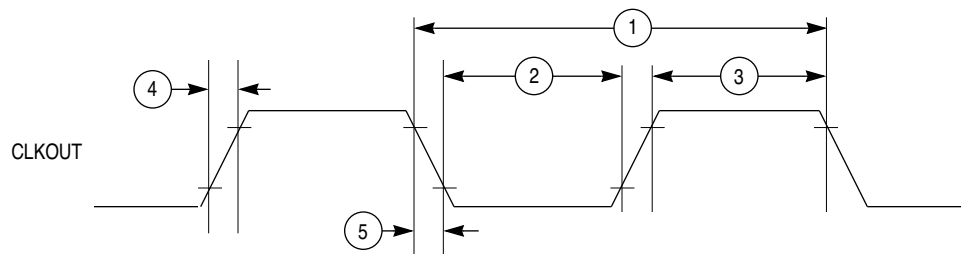
Num	Characteristic	Symbol	Min	Max	Unit
24	Data Out Valid to Negating Edge of $\overline{AS}$, $\overline{CS}$ (Fast Write Cycle)	t_{DVASN}	15	—	ns
25	$\overline{DS}$, $\overline{CS}$ Negated to Data Out Invalid (Data Out Hold)	$t_{SND OI}$	15	—	ns
26	Data Out Valid to $\overline{DS}$, $\overline{CS}$ 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) ⁵	t_{SNDI}	0	—	ns
29A	$\overline{DS}$, $\overline{CS}$ Negated to Data In High Impedance ^{5, 6}	t_{SHDI}	—	55	ns
30	CLKOUT Low to Data In Invalid (Fast Cycle Hold) ⁵	t_{CLDI}	15	—	ns
30A	CLKOUT Low to Data In High Impedance ⁵	t_{CLDH}	—	90	ns
31	$\overline{DSACK}[1:0]$ Asserted to Data In Valid ⁷	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) ⁸	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 ⁹	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
56	$\overline{RESET}$ Pulse Width (Reset Instruction)	t_{HRPW}	512	—	t_{cyc}
57	$\overline{BERR}$ Negated to $\overline{HALT}$ Negated (Rerun)	t_{BNHN}	0	—	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

Table 6 16.78 MHz AC Timing (Continued) $(V_{DD} \text{ and } V_{DDSYN} = 2.7 \text{ to } 3.6 \text{ Vdc}, V_{SS} = 0 \text{ Vdc}, T_A = T_L \text{ to } T_H)^1$

Num	Characteristic	Symbol	Min	Max	Unit
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 ¹⁰	t_{RSTA}	4	—	t_{cyc}
78	$\overline{RESET}$ Rise Time ^{11, 12}	t_{RSTR}	—	10	t_{cyc}

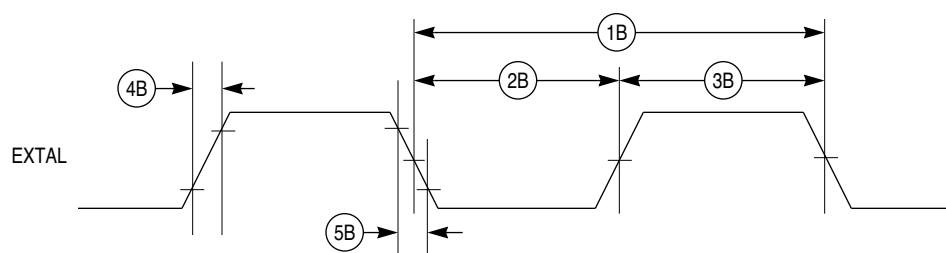
NOTES:

1. All AC timing is shown with respect to 2.0 V and 0.8 V 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. 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.
4. 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.
5. 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.
6. Maximum value is equal to $(t_{cyc} / 2) + 25$ ns.
7. 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 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 $\overline{BERR}$ low to clock low setup time (specification 27A) for the following clock cycle.
8. 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.
9. In the absence of $\overline{DSACK}[1:0]$, $\overline{BERR}$ is an asynchronous input using the asynchronous setup time (specification 47A).
10. 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} .
11. 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.
12. External logic must pull $\overline{RESET}$ high during this period in order for normal MCU operation to begin.



68300 CLKOUT TIM

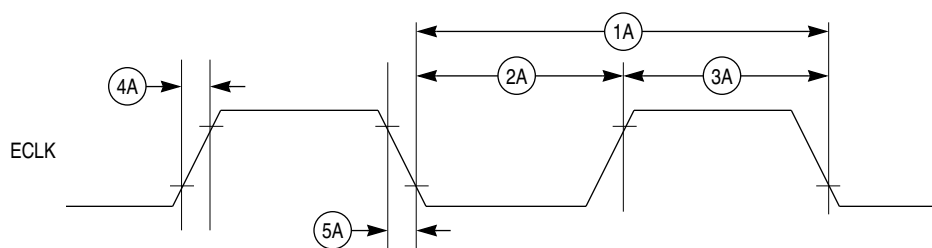
Figure 1 CLKOUT Output Timing Diagram



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

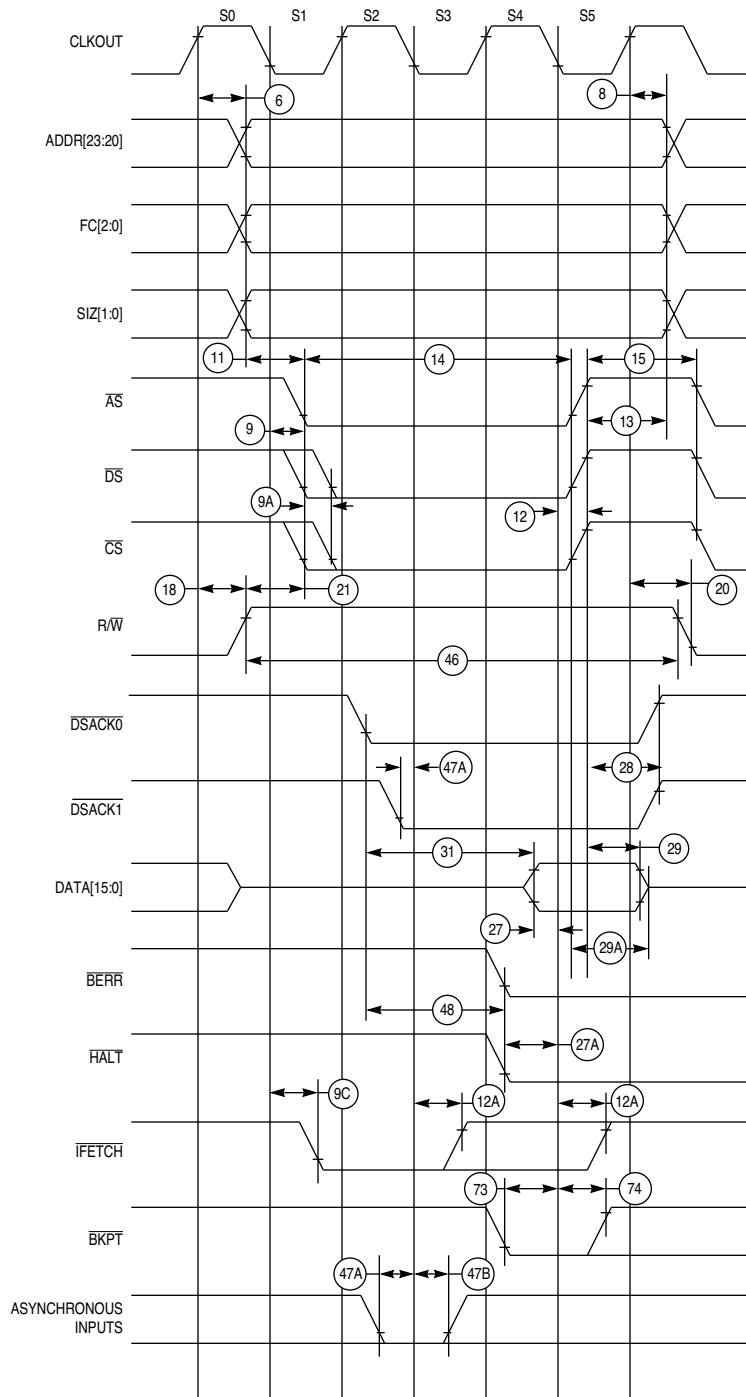
68300 EXT CLK INPUT TIM

Figure 2 External Clock Input Timing Diagram



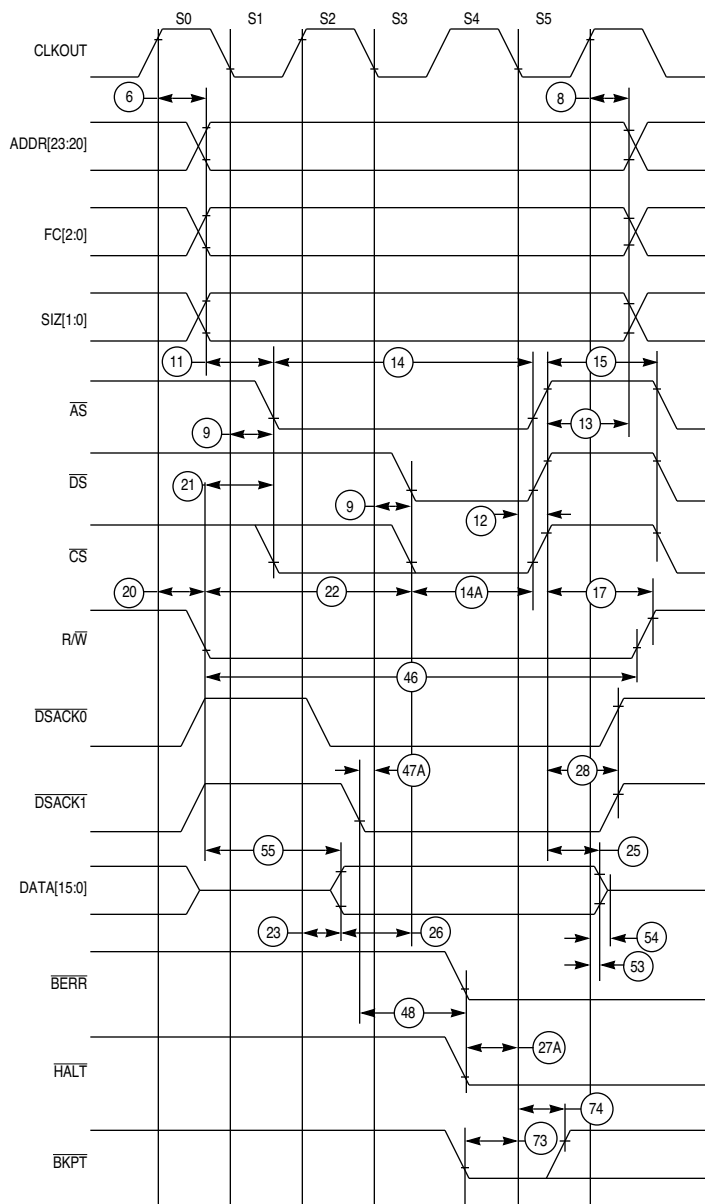
68300 ECLK OUTPUT TIM

Figure 3 ECLK Output Timing Diagram



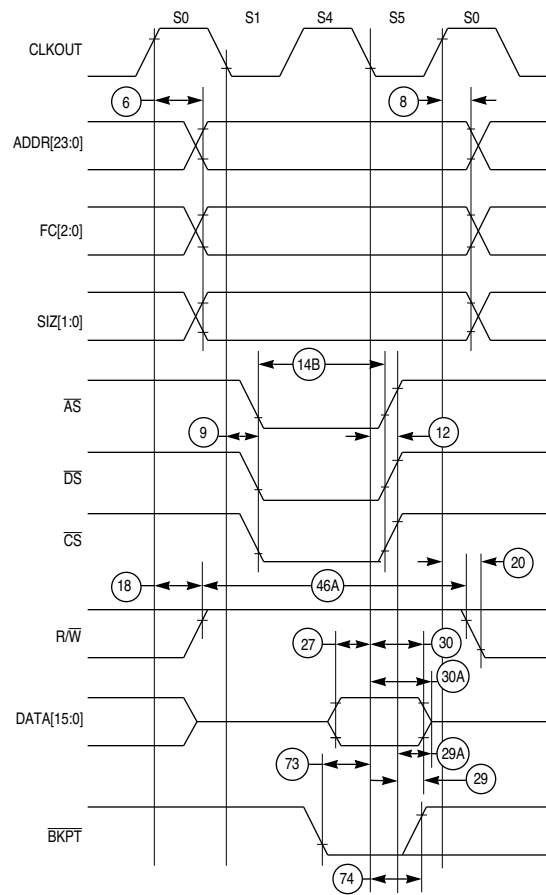
68300 RD CYC TIM

Figure 4 Read Cycle Timing Diagram



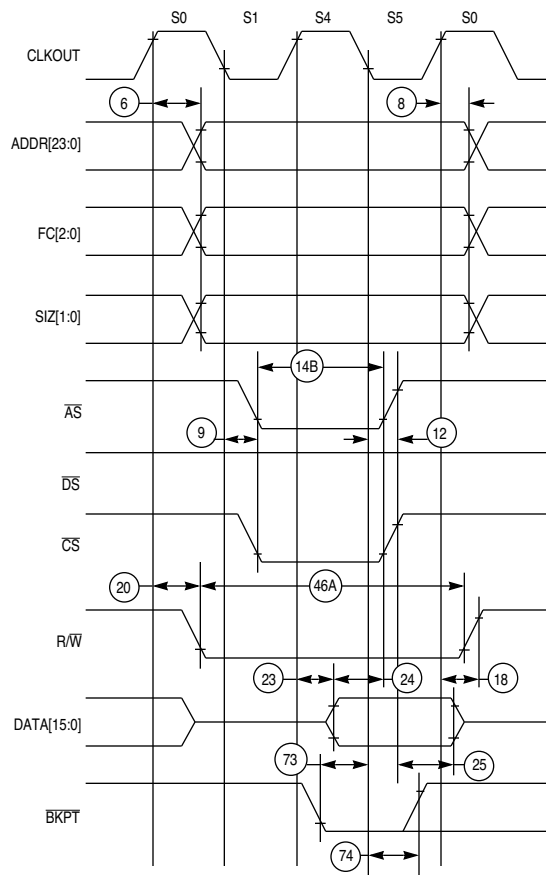
68300 WR CYC TIM

Figure 5 Write Cycle Timing Diagram



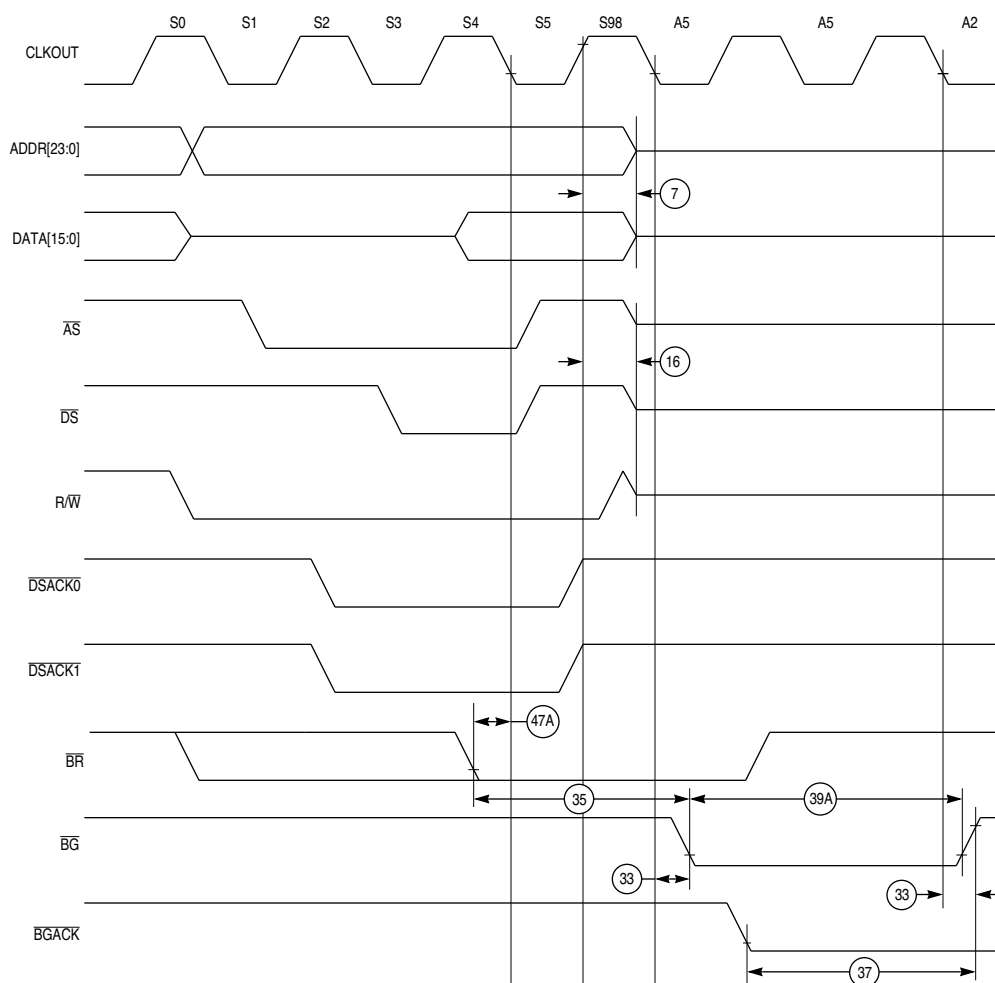
68300 FAST RD CYC TIM

Figure 6 Fast Termination Read Cycle Timing Diagram



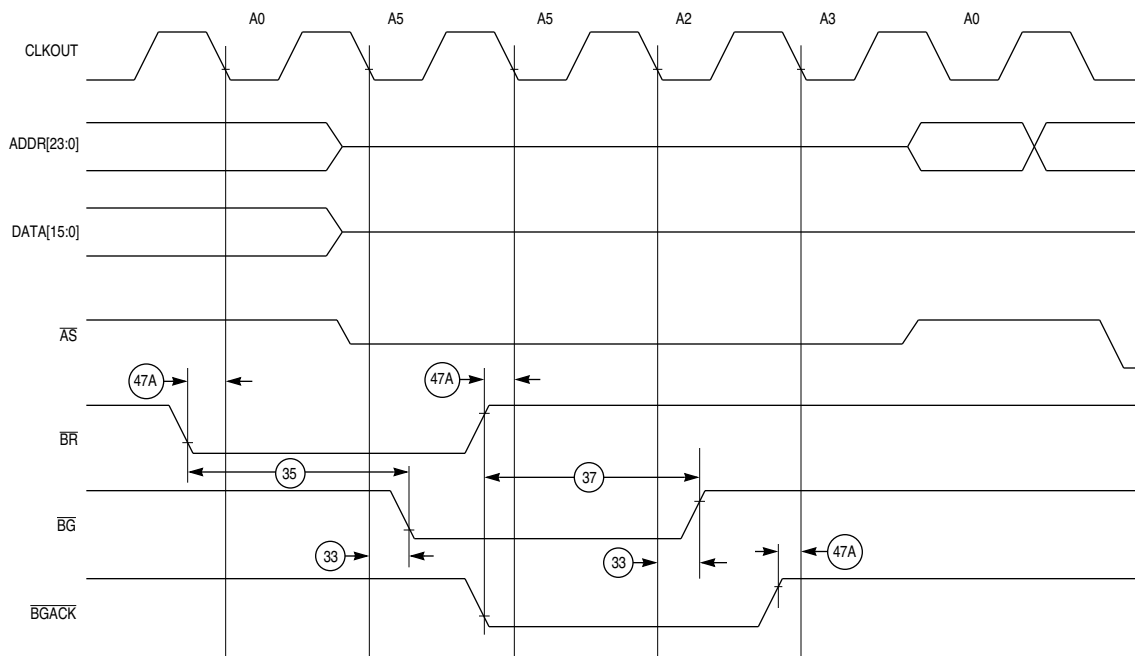
68300 FAST WR CYC TIM

Figure 7 Fast Termination Write Cycle Timing Diagram



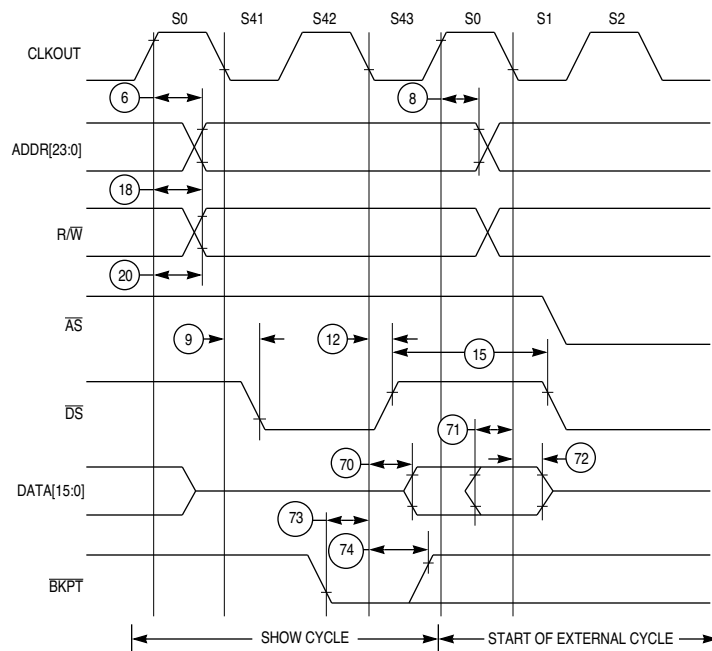
68300 BUS ARB TIM

Figure 8 Bus Arbitration Timing Diagram — Active Bus Case



68300 BUS ARB TIM IDLE

Figure 9 Bus Arbitration Timing Diagram — Idle Bus Case

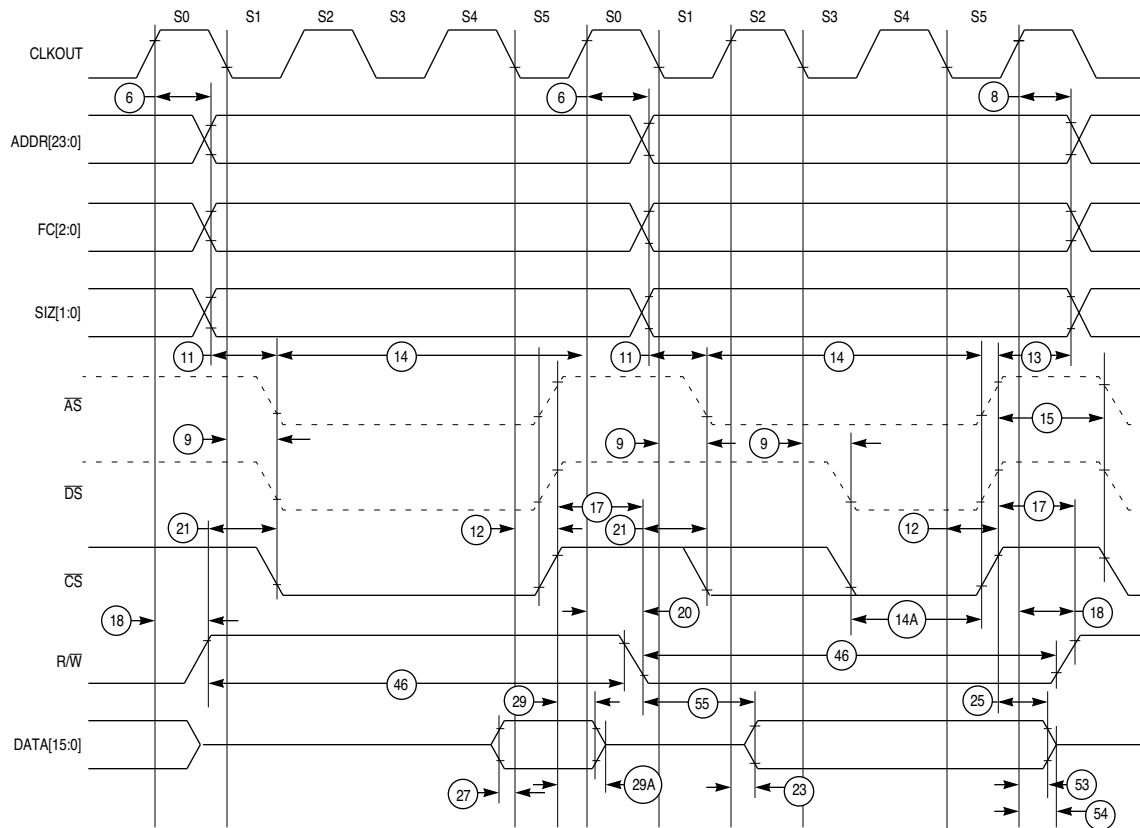


NOTE:

Show cycles can stretch during clock phase S42 when bus accesses take longer than two cycles due to IMB module wait-state insertion.

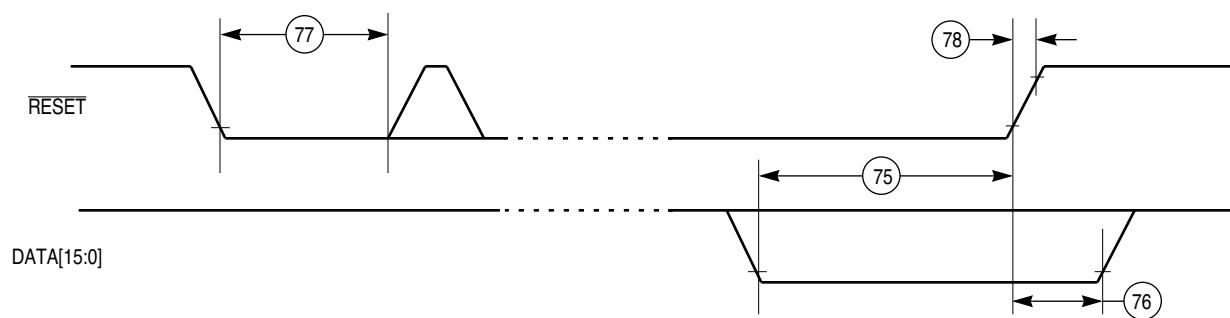
68300 SHW CYC TIM

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

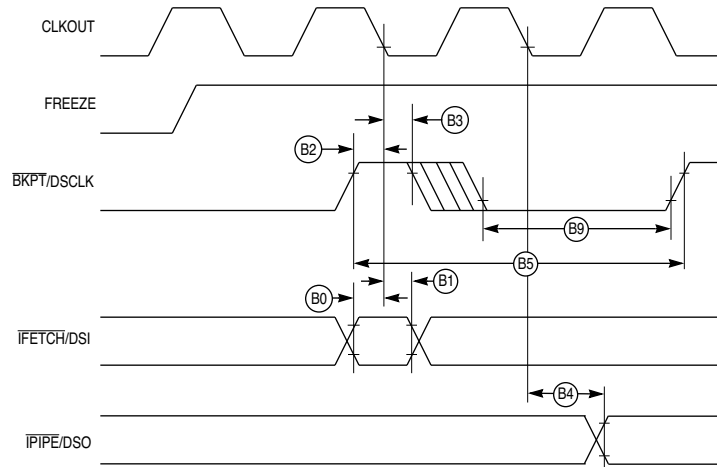
Table 7 Background Debugging Mode Timing

(V_{DD} and $V_{DDSYN} = 2.7$ to 3.6 Vdc, $V_{SS} = 0$ Vdc, $T_A = T_L$ to T_H)¹

Num	Characteristic	Symbol	Min	Max	Unit
B0	DSI Input Setup Time	t_{DSISU}	15	—	ns
B1	DSI Input Hold Time	t_{DSIH}	10	—	ns
B2	DSCLK Setup Time	t_{DSCSU}	15	—	ns
B3	DSCLK Hold Time	t_{DSCH}	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 $\overline{IFETCH}$ High Impedance	t_{IPZ}	—	50	ns
B8	CLKOUT High to $\overline{IFETCH}$ Valid	t_{IP}	—	50	ns
B9	DSCLK Low Time	t_{DSCLO}	1	—	t_{cyc}

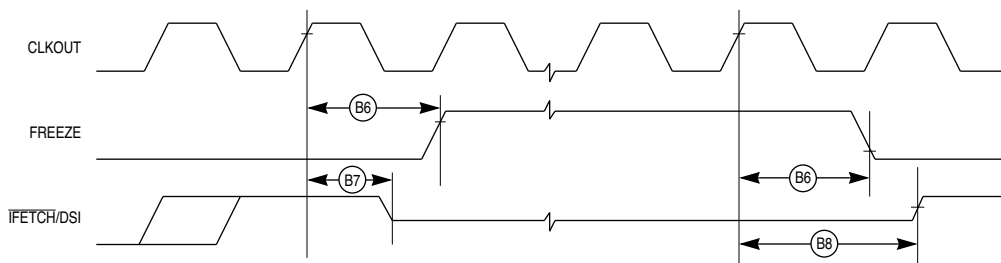
NOTES:

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

$$(V_{DD} \text{ and } V_{DDSYN} = 2.7 \text{ to } 3.6 \text{ Vdc}, V_{SS} = 0 \text{ Vdc}, T_A = T_L \text{ to } T_H)^1$$

Num	Characteristic	Symbol	Min	Max	Unit
E1	ECLK Low to Address Valid ²	t_{EAD}	—	60	ns
E2	ECLK Low to Address Hold	t_{EAH}	15	—	ns
E3	ECLK Low to $\overline{CS}$ Valid ($\overline{CS}$ Delay)	$t_{ECS D}$	—	150	ns
E4	ECLK Low to $\overline{CS}$ Hold	$t_{ECS H}$	15	—	ns
E5	$\overline{CS}$ Negated Width	$t_{ECS N}$	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) ³	t_{EACC}	386	—	ns
E14	Chip-Select Access Time (Read) ⁴	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 = $t_{Ecyc} - t_{EAD} - t_{EDSR}$.
4. Chip select access time = $t_{Ecyc} - t_{ECS D} - t_{EDSR}$.

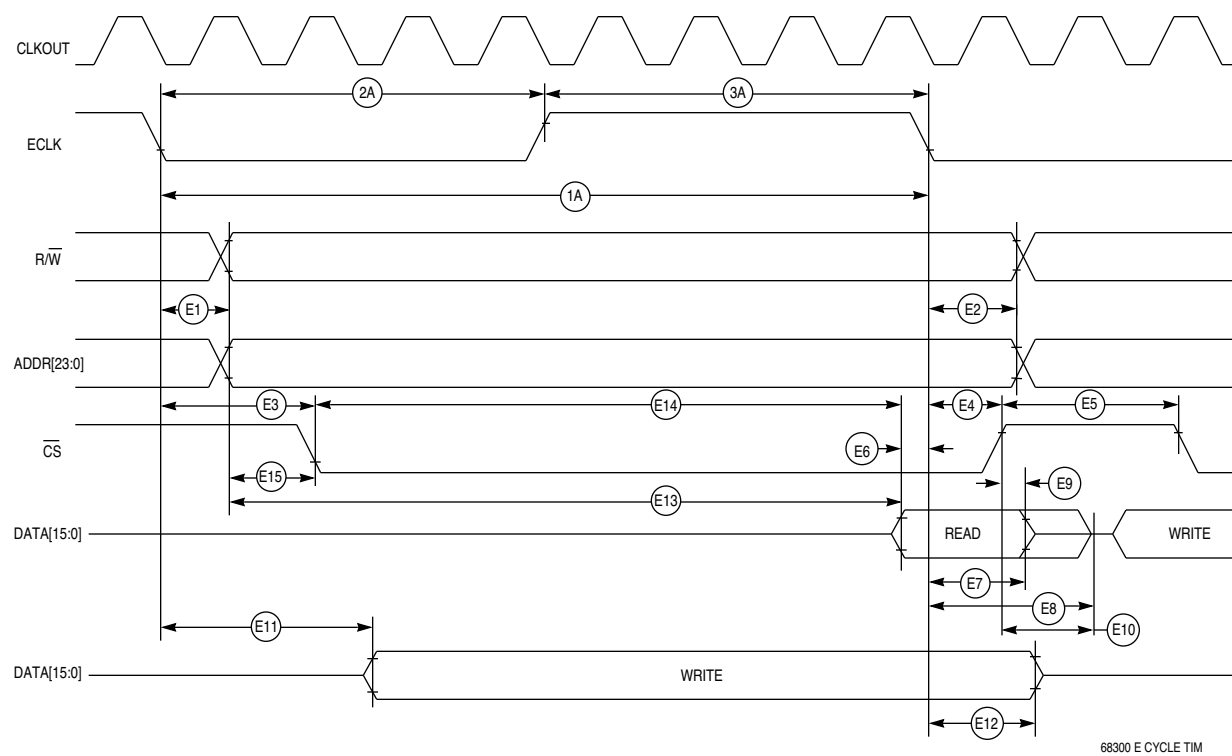


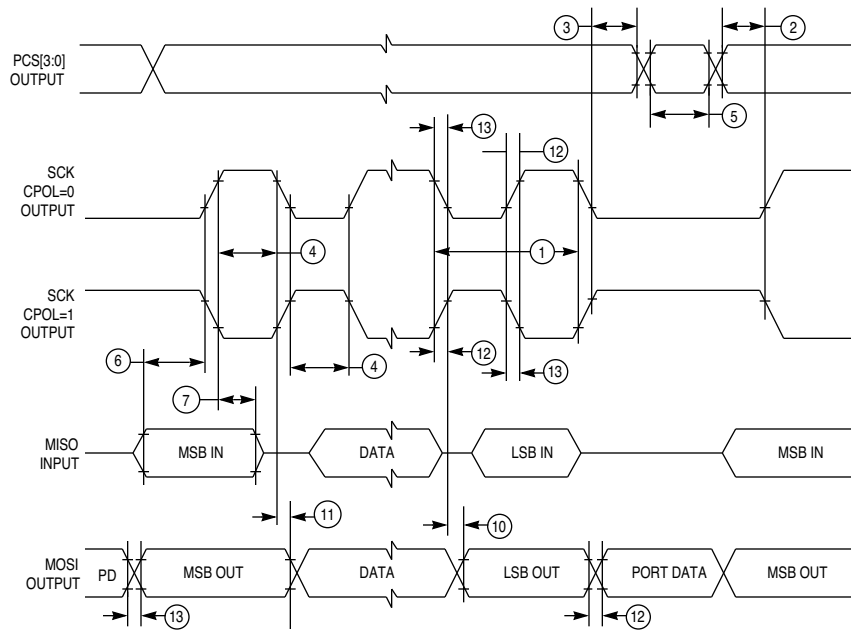
Figure 15 ECLK Timing Diagram

Table 9 QSPI Timing(V_{DD} and V_{DDSYN} = 2.7 to 3.6 Vdc, V_{SS} = 0 Vdc, T_A = T_L to T_H, 80 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 _{qcy}	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} – 60 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}	30 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

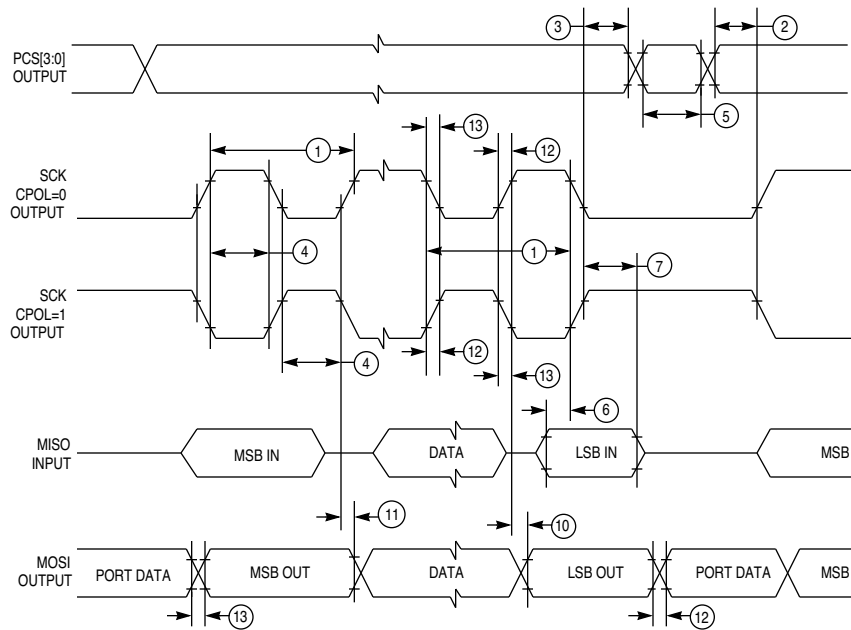
NOTES:

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.



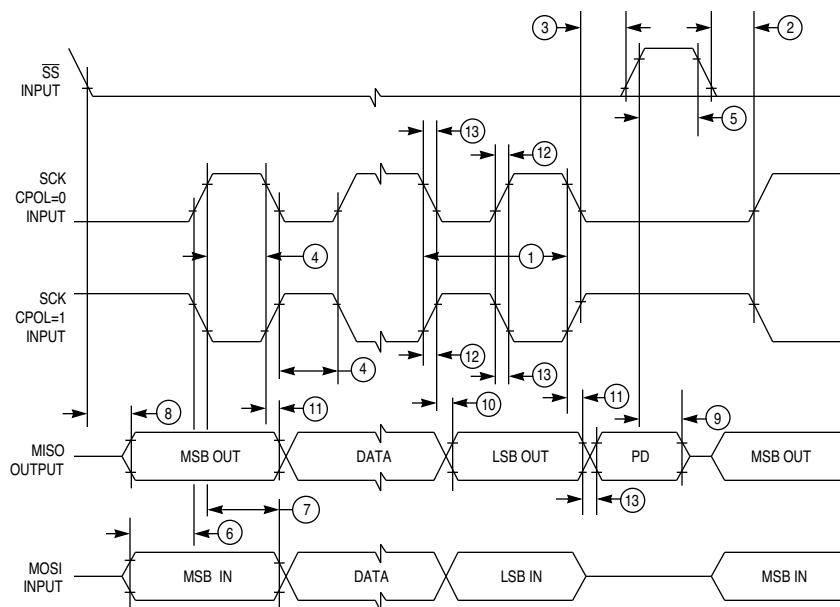
68300 QSPI MAST CPHA0

Figure 16 QSPI Timing — Master, CPHA = 0



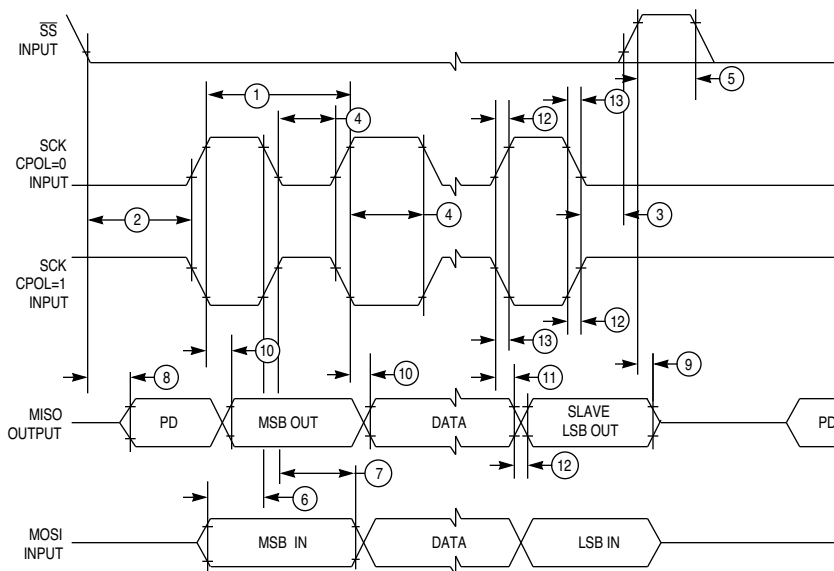
68300 QSPI MAST CPHA1

Figure 17 QSPI Timing — Master, CPHA = 1



68300 QSPI SLV CPHA0

Figure 18 QSPI Timing — Slave, CPHA = 0

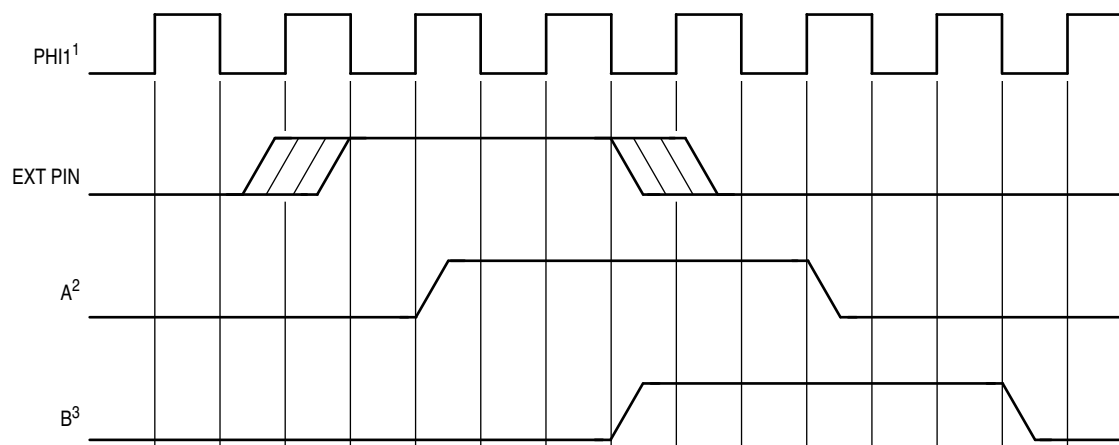


68300 QSPI SLV CPHA1

Figure 19 QSPI Timing — Slave, CPHA = 1

Table 10 General-Purpose Timer AC Characteristics

Num	Parameter	Symbol	Min	Max	Unit
1	Operating Frequency	Fclock	0	16.78	MHz
2	PCLK Frequency	Fpclk	0	1/4 Fclock	MHz
3	Pulse Width Input Capture	PWtim	2/Fclock	—	—
4	PWM Resolution	—	2/Fclock	—	—
5	IC/OC Resolution	—	4/Fclock	—	—
6	PCLK Width (PWM)	—	4/Fclock	—	—
7	PCLK Width (IC/OC)	—	4/Fclock	—	—
8	PAI Pulse Width	—	2/Fclock	—	—

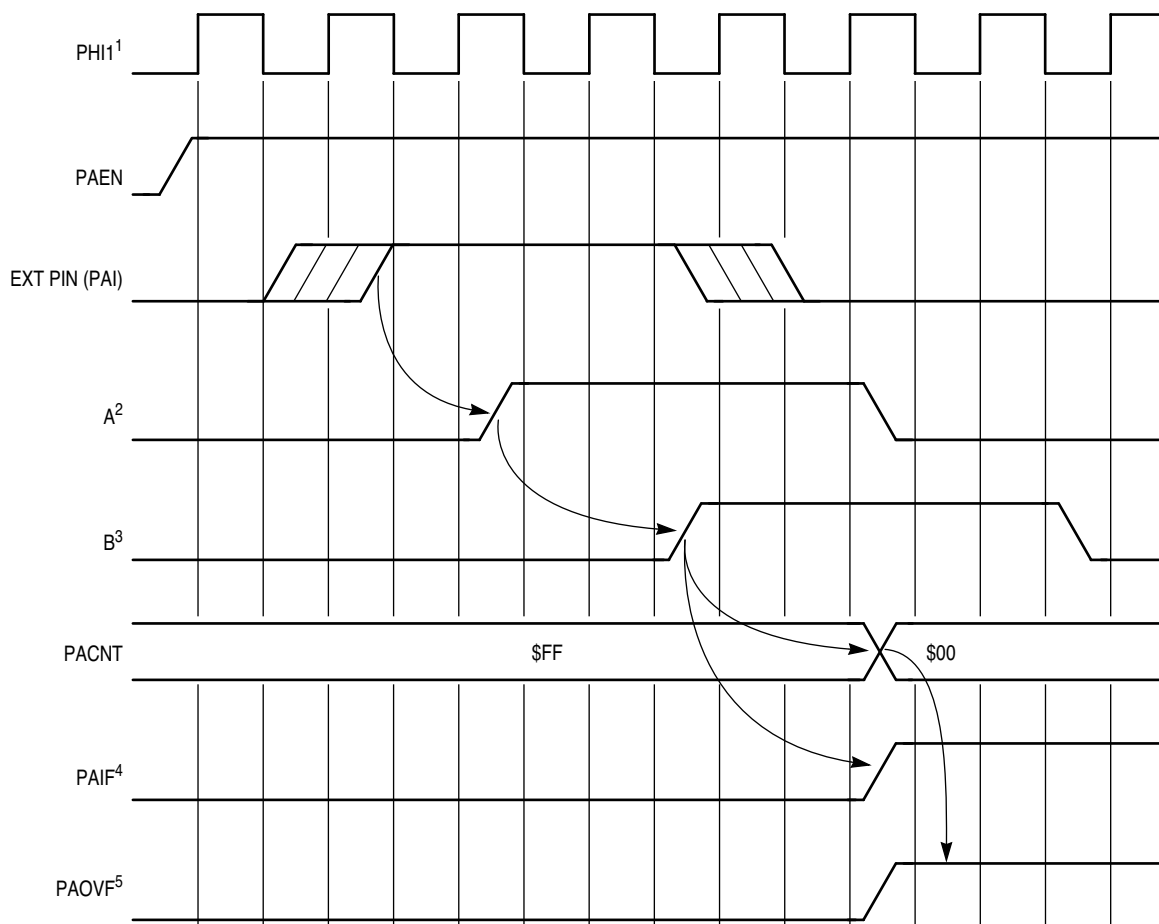


NOTES:

1. PHI1 IS THE SAME FREQUENCY AS THE SYSTEM CLOCK; HOWEVER, IT DOES NOT HAVE THE SAME TIMING.
2. A = INPUT SIGNAL AFTER THE SYNCHRONIZER.
3. B = "A" AFTER THE DIGITAL FILTER.

INPUT SIG CONDITIONER TIM

Figure 20 Input Signal Conditioner Timing

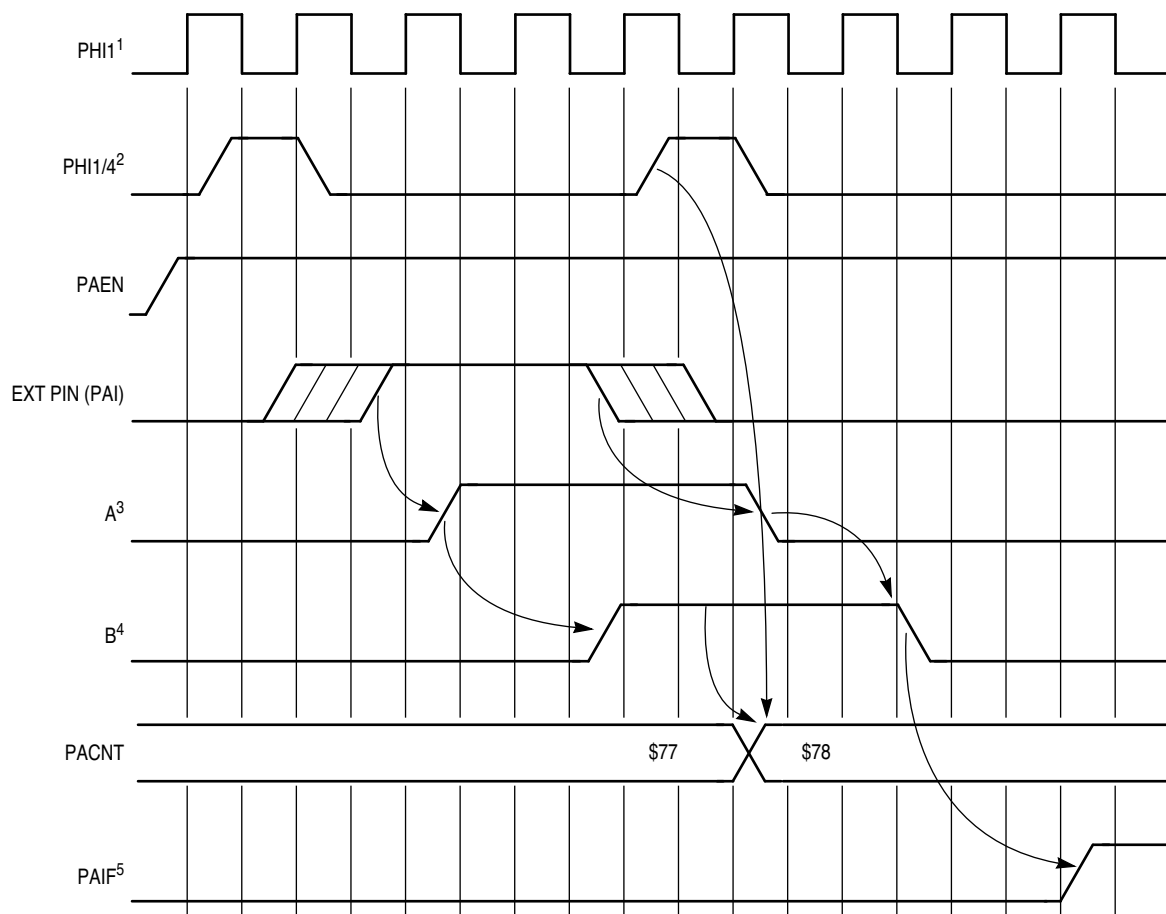


NOTES:

1. PHI1 IS THE SAME FREQUENCY AS THE SYSTEM CLOCK; HOWEVER, IT DOES NOT HAVE THE SAME TIMING.
2. A = PAI SIGNAL AFTER THE SYNCHRONIZER.
3. B = "A" AFTER THE DIGITAL FILTER.
4. THE EXTERNAL LEADING EDGE CAUSES THE PULSE ACCUMULATOR TO INCREMENT AND THE PAIF FLAG TO BE SET.
5. THE COUNTER TRANSITION FROM \$FF TO \$00 CAUSES THE PAOVF FLAG TO BE SET.

PULSE ACCUM ECM LEAD EDGE

Figure 21 Pulse Accumulator —Event Counting Mode (Leading Edge)

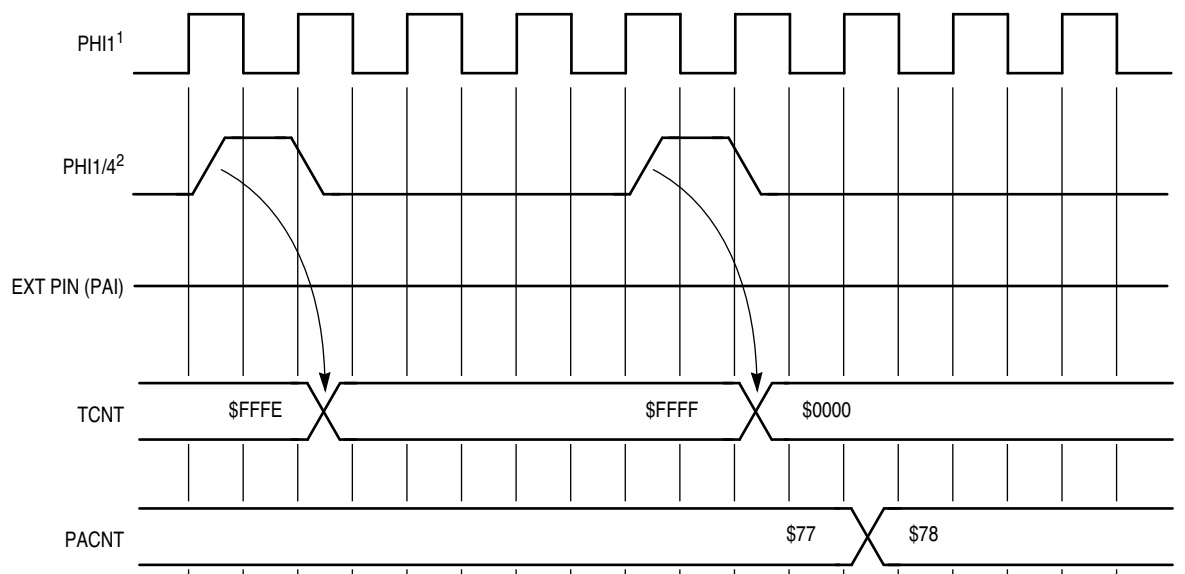


NOTES:

1. PHI1 HAS THE SAME FREQUENCY AS THE SYSTEM CLOCK; HOWEVER, IT DOES NOT HAVE THE SAME TIMING.
2. PHI1/4 CLOCKS PACNT WHEN GT-PAIF IS ASSERTED.
3. A = PAI SIGNAL AFTER THE SYNCHRONIZER.
4. B = "A" AFTER THE DIGITAL FILTER.
5. PAIF IS ASSERTED WHEN PAI IS NEGATED.

PULSE ACCUM GATED MODE

Figure 22 Pulse Accumulator —Gated Mode (Count While Pin High)

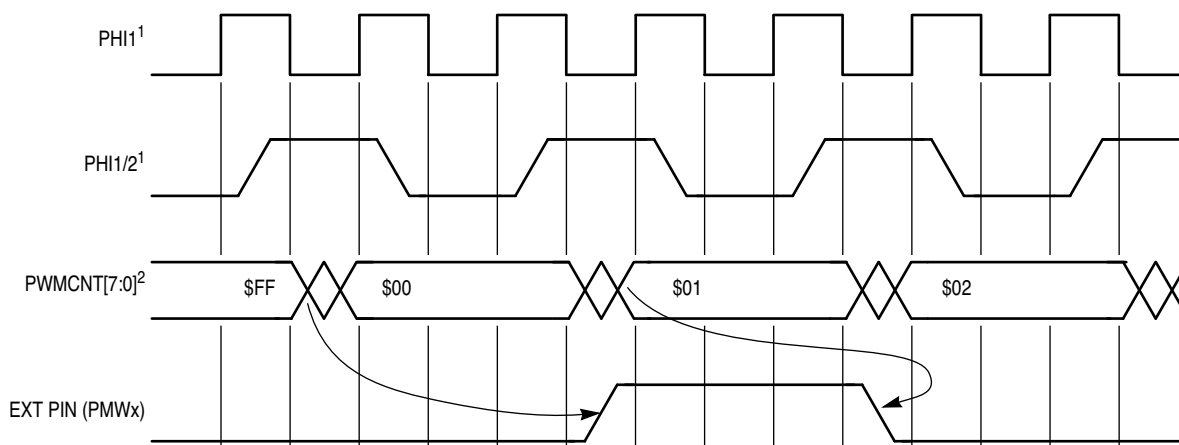


NOTES:

1. PHI1 HAS THE SAME FREQUENCY AS THE SYSTEM CLOCK; HOWEVER, IT DOES NOT HAVE THE SAME TIMING.
2. TCNT COUNTS AS A RESULT OF PHI1/4; PACNT COUNTS WHEN TCNT OVERFLOWS FROM \$FFFF TO \$0000 AND THE CONDITIONED PAI SIGNAL IS ASSERTED.

PULSE ACCUM TOF GATED MODE

Figure 23 Pulse Accumulator —Using TOF as Gated Mode Clock

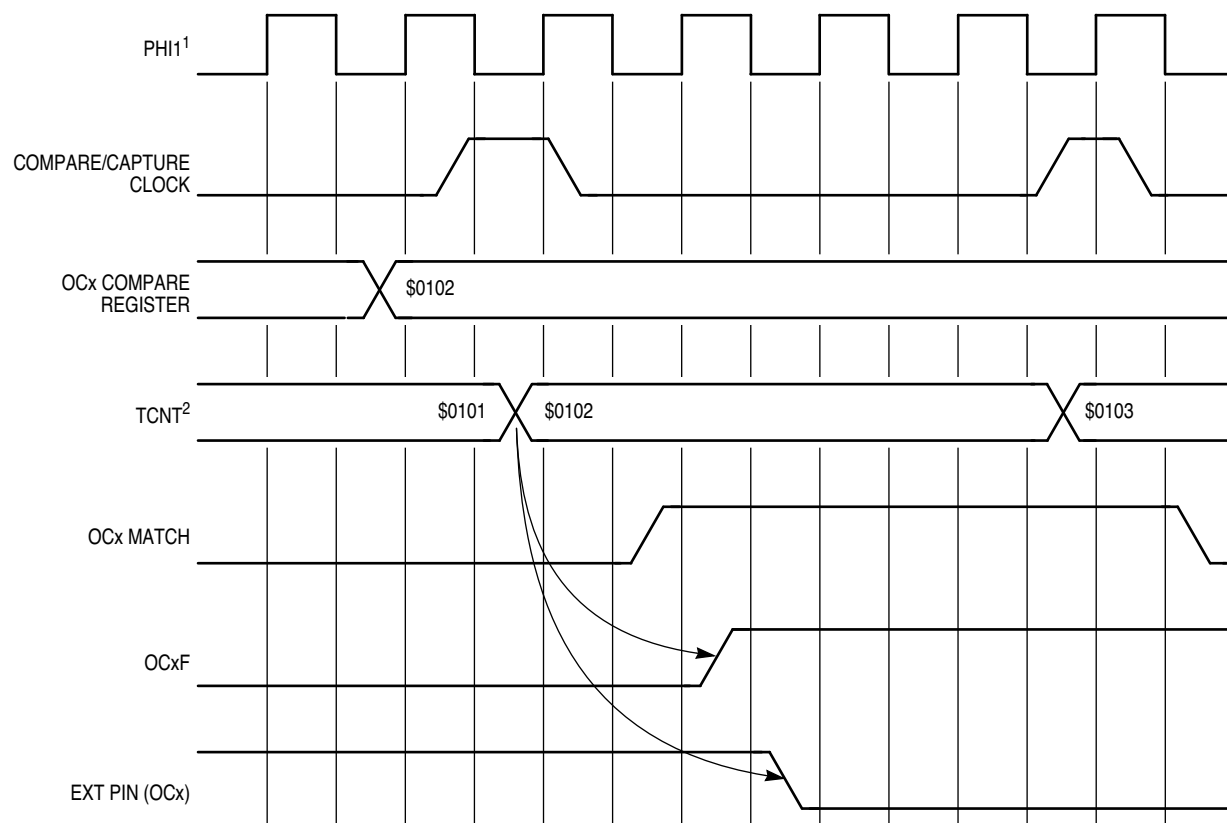


NOTES:

1. PHI1 IS THE SAME FREQUENCY AS THE SYSTEM CLOCK; HOWEVER, IT DOES NOT HAVE THE SAME TIMING.
2. WHEN THE COUNTER ROLLS OVER FROM \$FF TO \$00, THE PWM PIN IS SET TO LOGIC LEVEL ONE.
WHEN THE COUNTER EQUALS THE PWM REGISTER, THE PWM PIN IS CLEARED TO A LOGIC LEVEL ZERO.

PWMx FAST MODE

Figure 24 PWMx (PWMx Register = 01, Fast Mode)

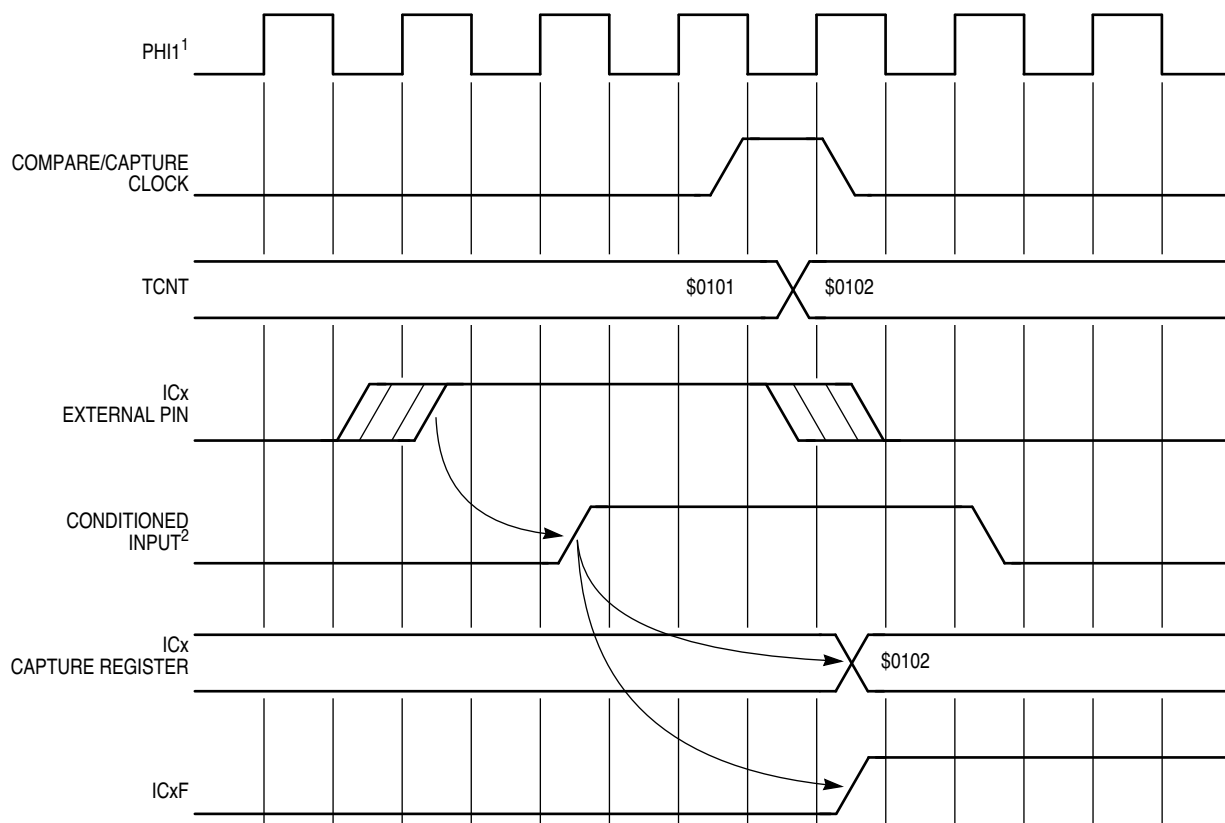


NOTES:

1. PHI1 IS THE SAME FREQUENCY AS THE SYSTEM CLOCK; HOWEVER, IT DOES NOT HAVE THE SAME TIMING.
2. WHEN THE TCNT MATCHES THE OCx COMPARE REGISTER, THE OCx FLAG IS SET FOLLOWED BY THE OCx PIN CHANGING STATE.

OUTPUT COMPARE

Figure 25 Output Compare (Toggle Pin State)

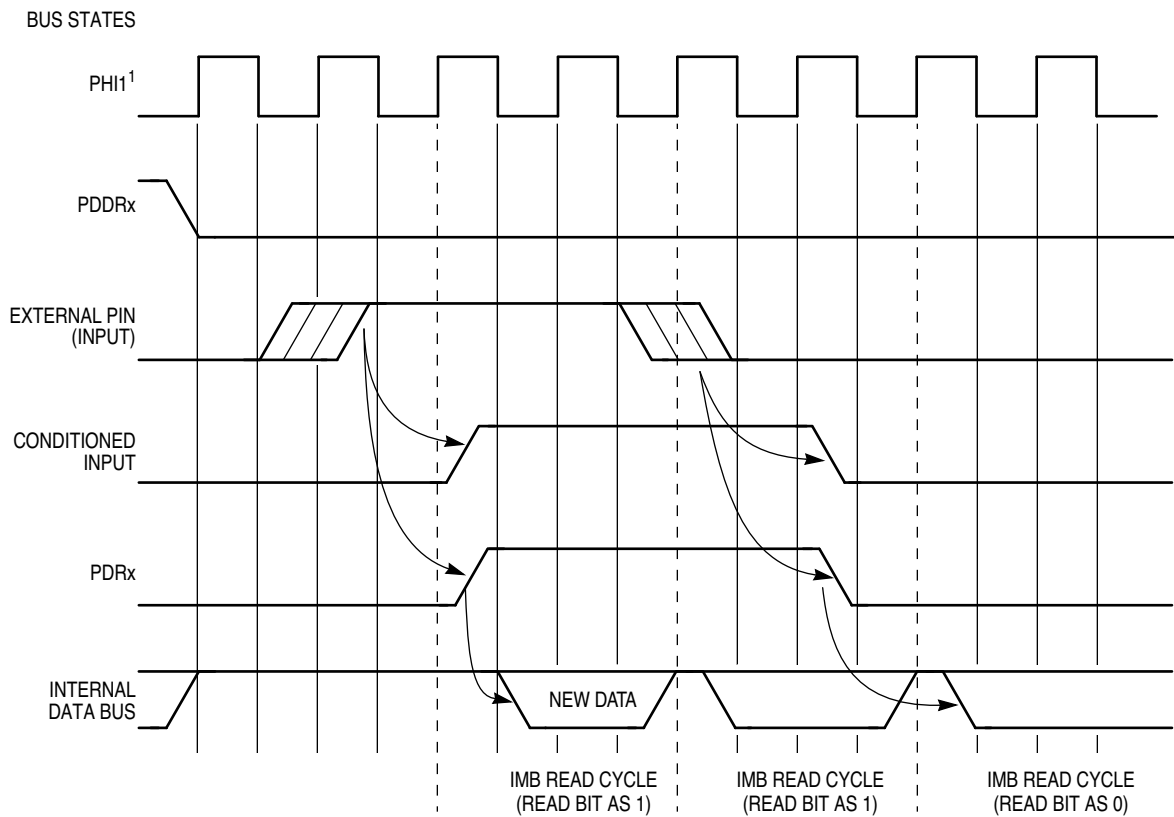


NOTES:

1. PHI1 IS THE SAME FREQUENCY AS THE SYSTEM CLOCK; HOWEVER, IT DOES NOT HAVE THE SAME TIMING.
2. THE CONDITIONED INPUT SIGNAL CAUSES THE CURRENT VALUE OF THE TCNT TO BE LATCHED BY THE ICx CAPTURE REGISTER. THE ICxF FLAG IS SET AT THE SAME TIME.

INPUT CAPTURE

Figure 26 Input Capture (Capture on Rising Edge)

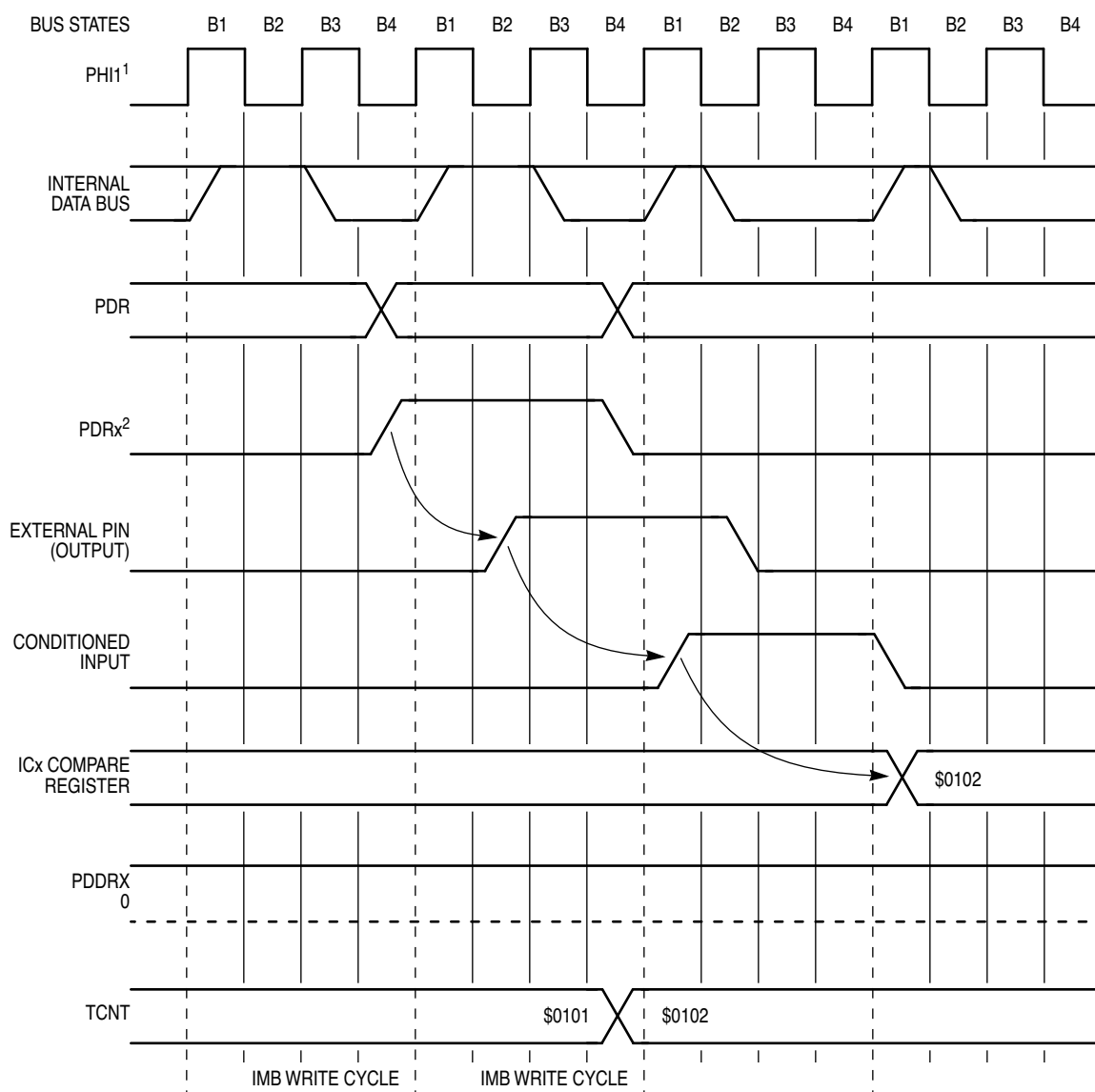


NOTES:

1. PHI1 IS THE SAME FREQUENCY AS THE SYSTEM CLOCK; HOWEVER, IT DOES NOT HAVE THE SAME TIMING.

GENERAL PURPOSE INPUT

Figure 27 General-Purpose Input

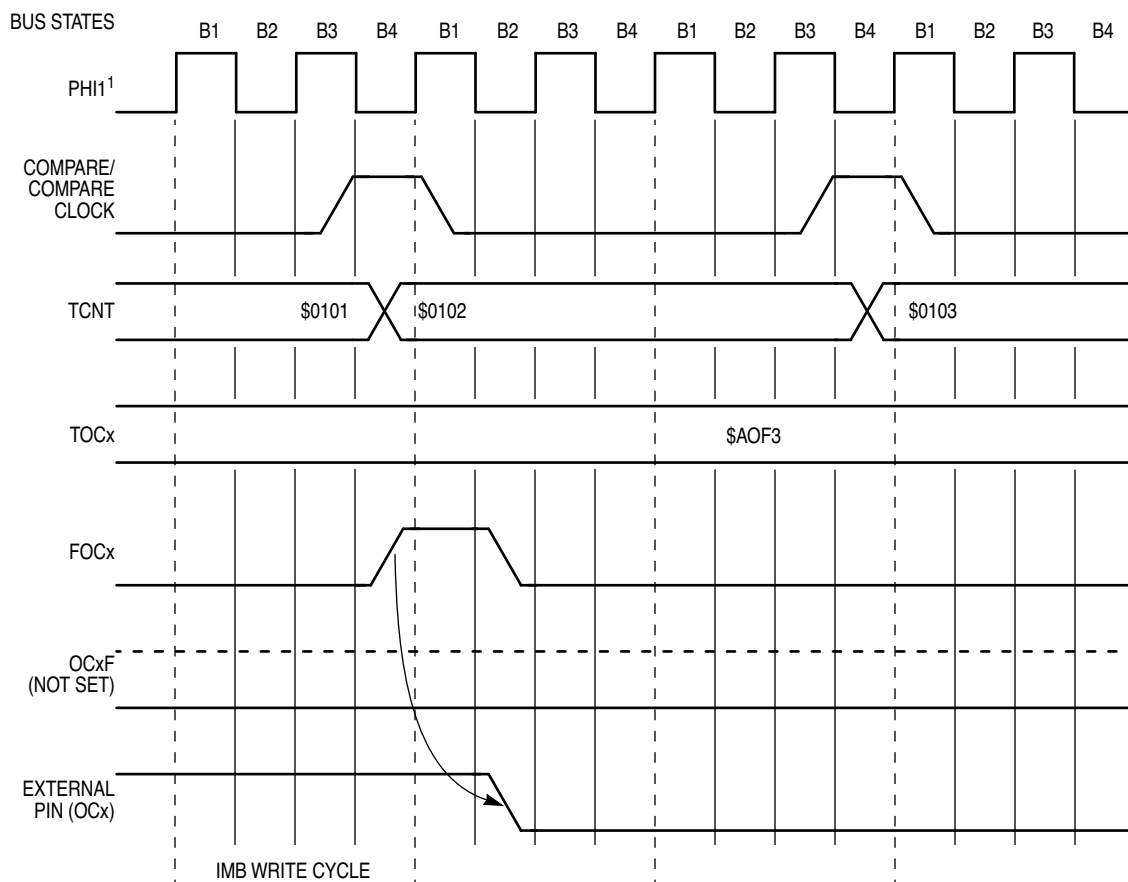


NOTES:

1. PHI1 IS THE SAME FREQUENCY AS THE SYSTEM CLOCK; HOWEVER, IT DOES NOT HAVE THE SAME TIMING.
2. WHEN THE BIT VALUE IS DRIVEN ON THE PIN, THE INPUT CIRCUIT SEES THE SIGNAL. AFTER IT IS CONDITIONED, IT CAUSES THE CONTENTS OF THE TCNT TO BE LATCHED INTO THE ICx COMPARE REGISTER.

GENERAL PURPOSE OUTPUT

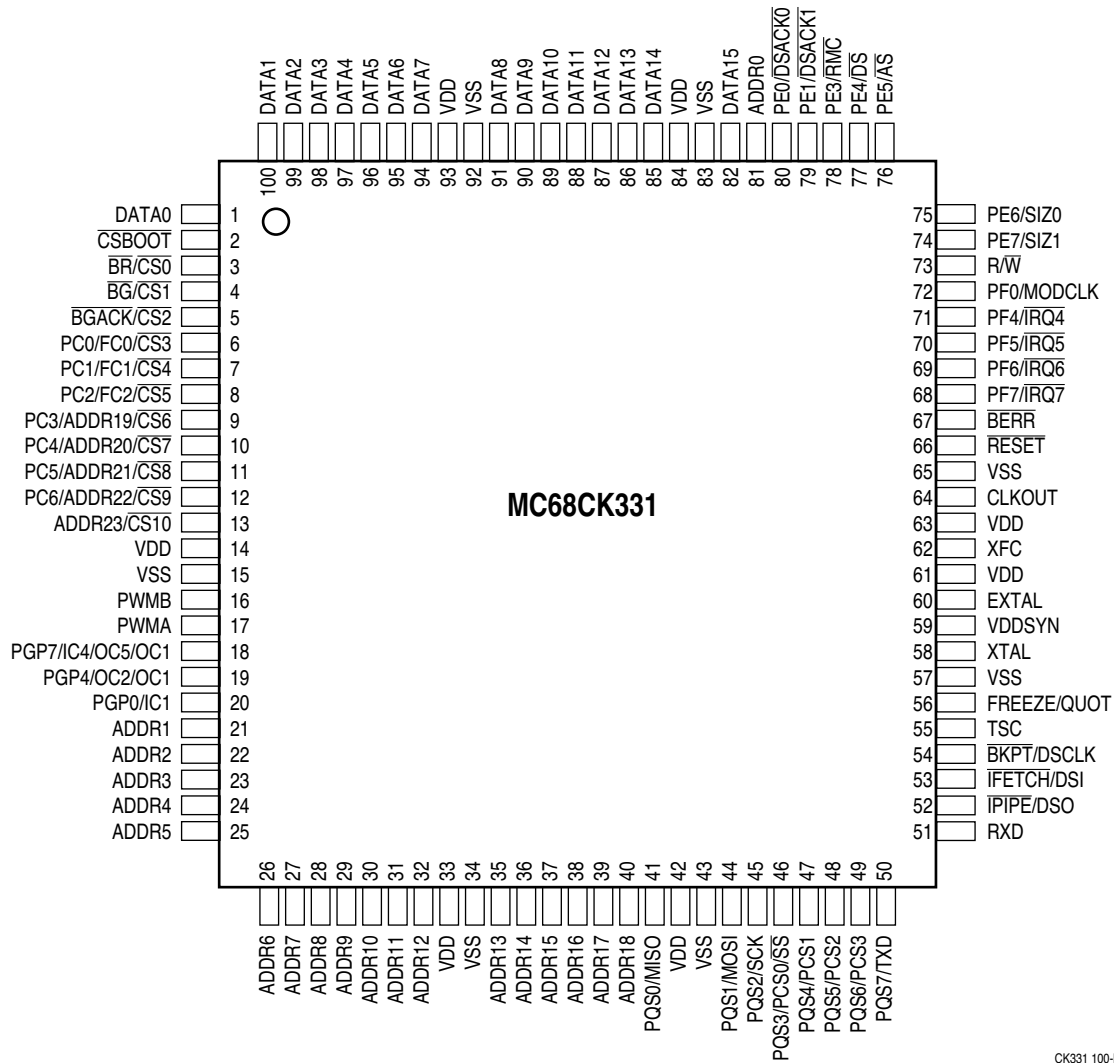
Figure 28 General-Purpose Output (Causes Input Capture)



NOTES:
1. PHI1 IS THE SAME FREQUENCY AS THE SYSTEM CLOCK; HOWEVER, IT DOES NOT HAVE THE SAME TIMING.

FORCE COMPARE

Figure 29 Force Compare (CLEAR)



CK331 100-PIN TQFP

Figure 30 MC68CK331 Pin Assignments for 100-Pin Package

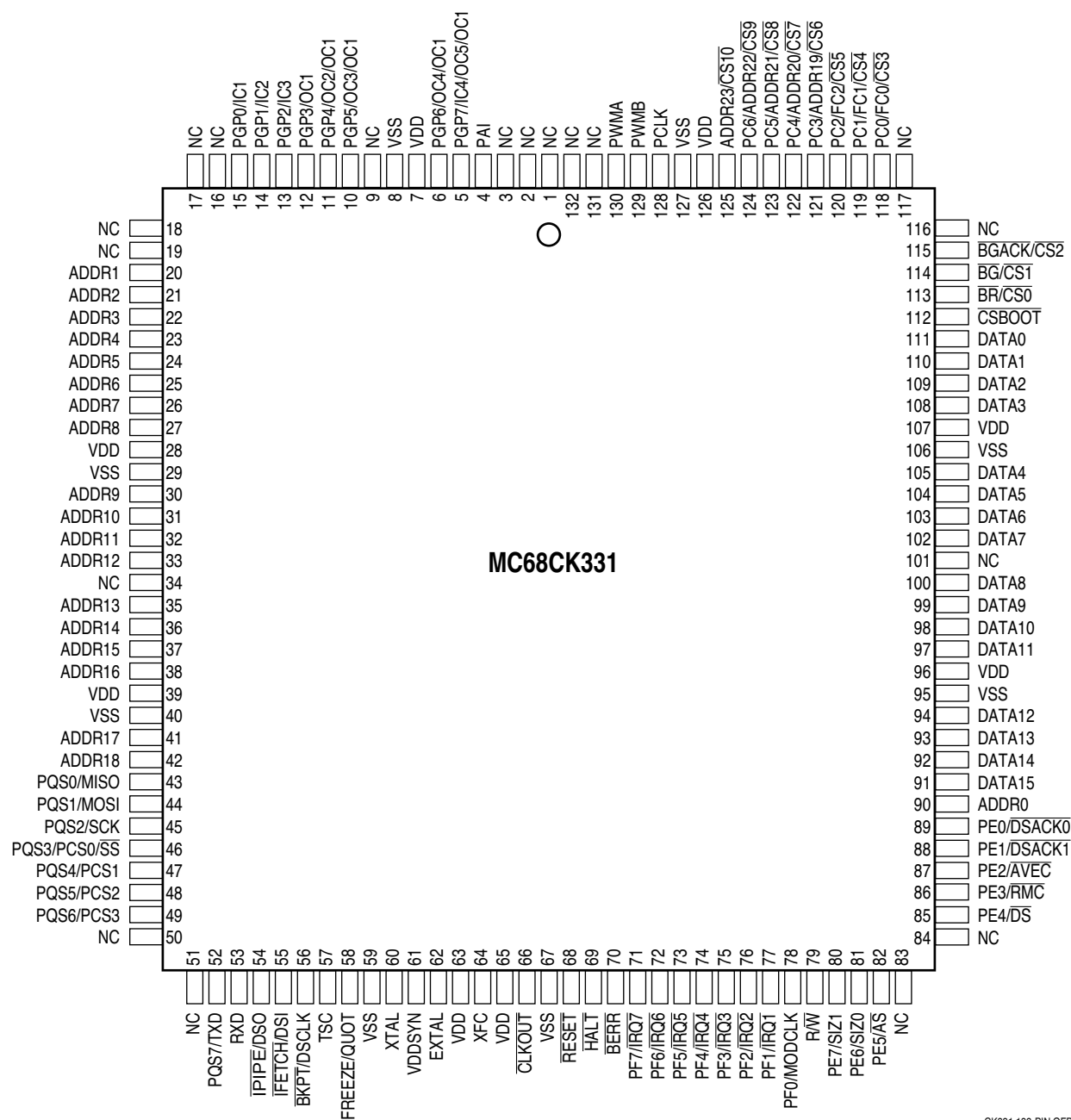
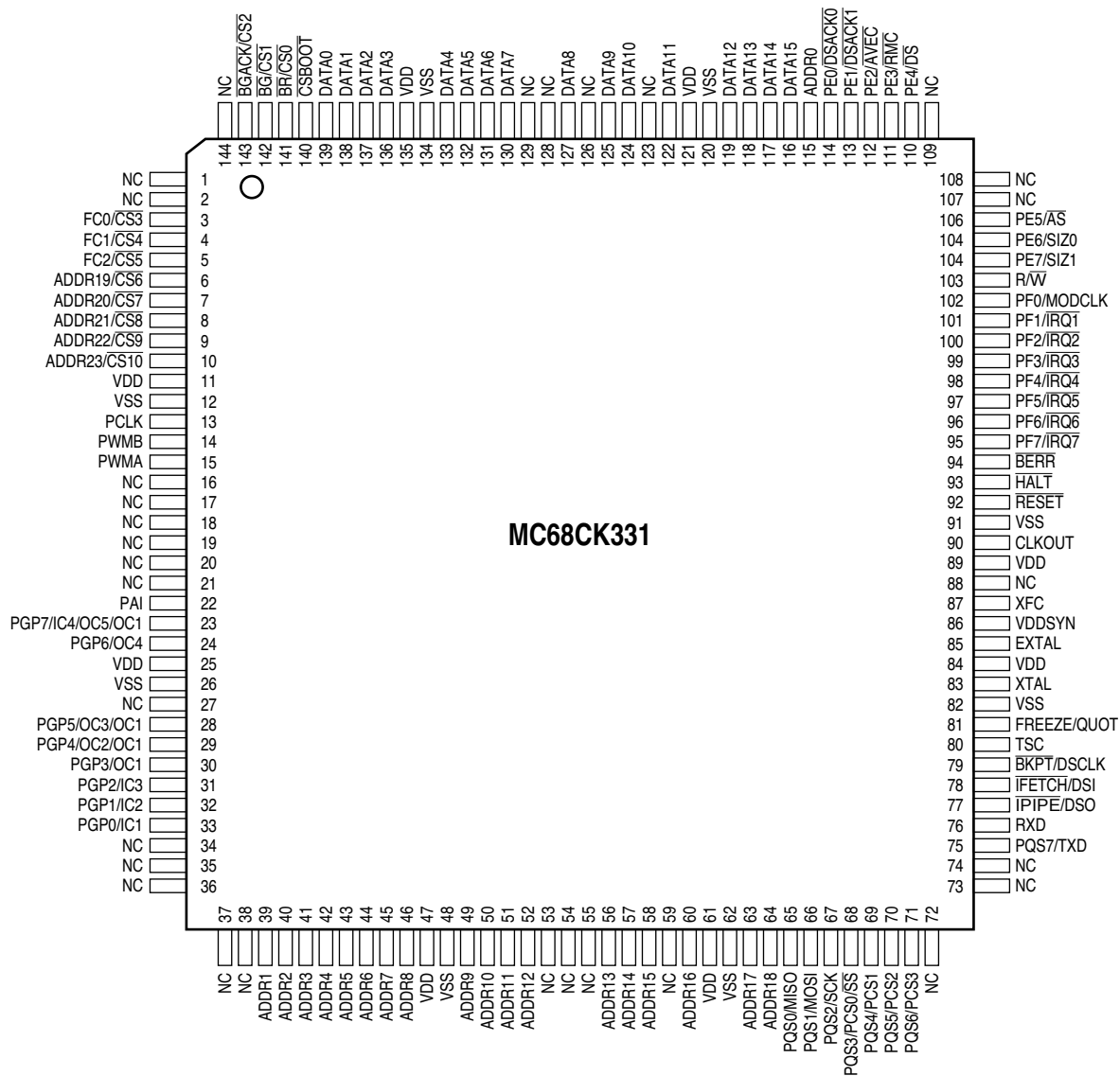


Figure 31 MC68CK331 Pin Assignments for 132-Pin Package



CK331 144-PIN QFP

Figure 32 MC68CK331 Pin Assignments for 144-Pin Package

Table 11 MC68CK331PU 100-Pin TQFP Pin Assignments

Pin	Description	Pin	Description	Pin	Description	Pin	Description
1	DATA0	26	ADDR6	51	RXD	76	PE5/AS
2	CSBOOT	27	ADDR7	52	IPIPE/DSO	77	PE4/DS
3	BR/CS0	28	ADDR8	53	IFETCH/DSI	78	PE3/RMC
4	BG/CS0	29	ADDR9	54	BKPT/DSCLK	79	PE1/DSACK1
5	BGACK/CS2	30	ADDR10	55	TSC	80	PE0/DSACK0
6	PC0/FC0/CS3	31	ADDR11	56	FREEZE/QUOT	81	ADDR0
7	PC1/FC1/CS4	32	ADDR12	57	V _{SS}	82	DATA15
8	PC2/FC2/CS5	33	V _{DD}	58	V _{DD}	83	V _{SS}
9	PC3/ADDR19/CS6	34	V _{SS}	59	V _{DDSYN}	84	V _{DD}
10	PC4/ADDR20/CS7	35	ADDR13	60	EXTAL	85	DATA14
11	PC5/ADDR21/CS8	36	ADDR14	61	V _{DD}	86	DATA13
12	PC6/ADDR22/CS9	37	ADDR15	62	XFC	87	DATA12
13	ADDR23/CS10	38	ADDR16	63	V _{DD}	88	DATA11
14	V _{DD}	39	ADDR17	64	CLKOUT	89	DATA10
15	V _{SS}	40	ADDR18	65	V _{SS}	90	DATA9
16	PWMB	41	PQS0/MISO	66	RESET	91	DATA8
17	PWMA	42	VDD	67	BERR	92	V _{SS}
18	PGP7/IC4/OC5/OC1	43	VSS	68	PF7/IRQ7	93	V _{DD}
19	PGP4/OC2/OC1	44	PQS1/MOSI	69	PF6/IRQ6	94	DATA7
20	PGP0/IC1	45	PQS2/SCK	70	PF5/IRQ5	95	DATA6
21	ADDR1	46	PQS3/PCS0/SS	71	PF4/IRQ4	96	DATA5
22	ADDR2	47	PQS4/PCS1	72	PF0/MODCLK	97	DATA4
23	ADDR3	48	PQS5/PCS2	73	R/W	98	DATA3
24	ADDR4	49	PQS6/PCS3	74	PE7/SIZ1	99	DATA2
25	ADDR5	50	PQS7/TXD	75	PE6/SIZ0	100	DATA1

Table 12 MC68CK331PU Deleted Function Pin List

Module	Description	Tied	Lost Function
SIM	HALT	High	Single-step, double bus fault
	PE2/AVEC	High	Must use chip-select for AVEC
	PF3/IRQ3	High	Level 3 interrupt request, port pin
	PF2/IRQ2	High	Level 2 interrupt request, port pin
	PF1/IRQ1	High	Level 1 interrupt request, port pin
GPT	PGP1/IC2	High	Input capture pin
	PGP2/IC3	High	Input capture pin
	PGP3/OC1	High	Output compare pin
	PGP5/OC3	High	Output compare pin
	PGP6/OC4	High	Output compare pin
	PAI	High	Pulse accumulator input
	PCLK	High	External GPT clock reference

