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

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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] $V_{NEGCLMAP} \cong -0.3$ 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 (TJ) 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:

$$P_D = K \div (T_J + 273°C) \quad (2)$$

Solving equations 1 and 2 for K gives:

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

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_{lpll}	—	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 $f_{sys} = f_{VCO} \div 4$. 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}.
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	µA
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	µA
6	CMOS Output High Voltage[2, 3] I_{OH} = –10.0 µA 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 µA 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, $\overline{\text{IPIPE}}$ I_{OL} = 2.6 mA Group 2 and Group 4 I/O pins, $\overline{\text{CSBOOT}}$, BG/$\overline{\text{CS}}$ 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 × 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 —	µA
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 µA
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 µA µA µA
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, IPIPE Group 2 I/O Pins and CSBOOT, BG/CS Group 3 I/O Pins Group 4 I/O Pins	C_L	— — — —	80 80 80 80	pF

NOTES:

1. Applies to:
   QSM pins
   IRQ[7:1], RESET, EXTAL, TSC, RMC, BKPT/DSCLK, IFETCH/DSI
2. Input-Only Pins: TSC, BKPT/DSCLK, RXD
   Output-Only Pins: CSBOOT, BG/CS, CLKOUT, FREEZE/QUOT, IPIPE/DSO
   Input/Output Pins:
   Group 1: DATA[15:0], 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]
   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
3. 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.
4. Current measured at maximum system clock frequency.
5. Total operating current is the sum of the appropriate V_{DD} supply and V_{DDSYN} supply current.
6. 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.
7. Input capacitance is periodically sampled rather than 100% tested.

Table 6 16.78 MHz AC 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
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_{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[2]	t_{XCHL}	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_{XCrf}	—	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/$\overline{W}$ 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} 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_{SNDOI}	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} 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
74	$\overline{\text{BKPT}}$ 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	$\overline{\text{RESET}}$ Assertion Time[10]	t_{RSTA}	4	—	t_{cyc}
78	$\overline{\text{RESET}}$ 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 $\overline{\text{AS}}$ and $\overline{\text{DS}}$ or $\overline{\text{CS}}$. The amount of skew depends on the relative loading of these signals. When loads are kept within specified limits, skew will not cause $\overline{\text{AS}}$ and $\overline{\text{DS}}$ to fall outside the limits shown in specification 9.
4. If multiple chip-selects are used, $\overline{\text{CS}}$ 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 $\overline{\text{CS}}$ 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 $\overline{\text{DS}}$ or $\overline{\text{CS}}$ 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 $\overline{\text{DSACK}}$[1:0] low to data setup time (specification 31) and $\overline{\text{DSACK}}$[1:0] low to $\overline{\text{BERR}}$ 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. $\overline{\text{BERR}}$ must satisfy only the late $\overline{\text{BERR}}$ low to clock low setup time (specification 27A) for the following clock cycle.
8. To ensure coherency during every operand transfer, $\overline{\text{BG}}$ is not asserted in response to $\overline{\text{BR}}$ until after all cycles of the current operand transfer are complete.
9. In the absence of $\overline{\text{DSACK}}$[1:0], $\overline{\text{BERR}}$ is an asynchronous input using the asynchronous setup time (specification 47A).
10. After external $\overline{\text{RESET}}$ negation is detected, a short transition period (approximately 2) t_{cyc} elapses, then the SIM drives $\overline{\text{RESET}}$ low for 512 t_{cyc}.
11. External assertion of the $\overline{\text{RESET}}$ input can overlap internally-generated resets. To insure that an external reset is recognized in all cases, $\overline{\text{RESET}}$ must be asserted for at least 590 CLKOUT cycles.
12. External logic must pull $\overline{\text{RESET}}$ high during this period in order for normal MCU operation to begin.

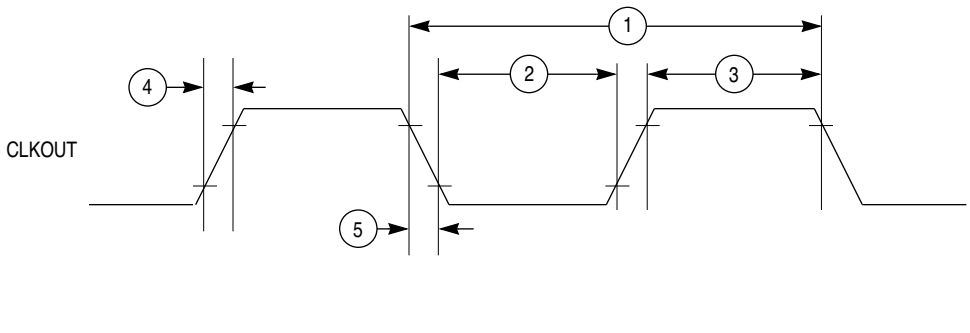
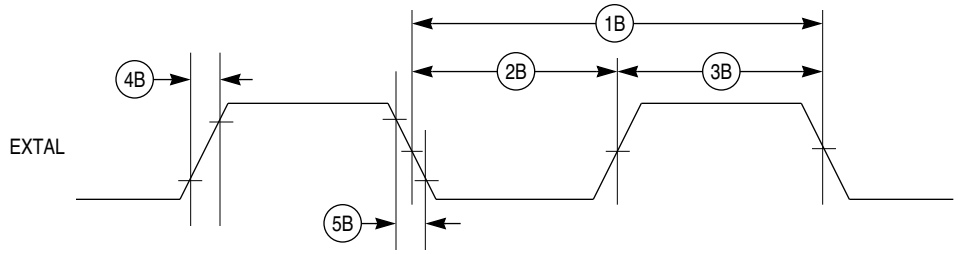


Figure 1 CLKOUT Output Timing Diagram



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

68300 EXT CLK INPUT TIM

Figure 2 External Clock Input Timing Diagram

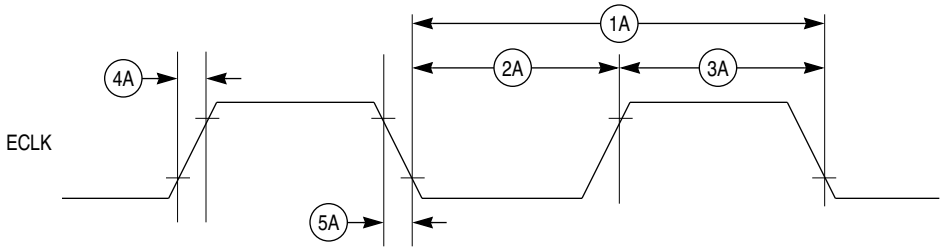


Figure 3 ECLK Output Timing Diagram

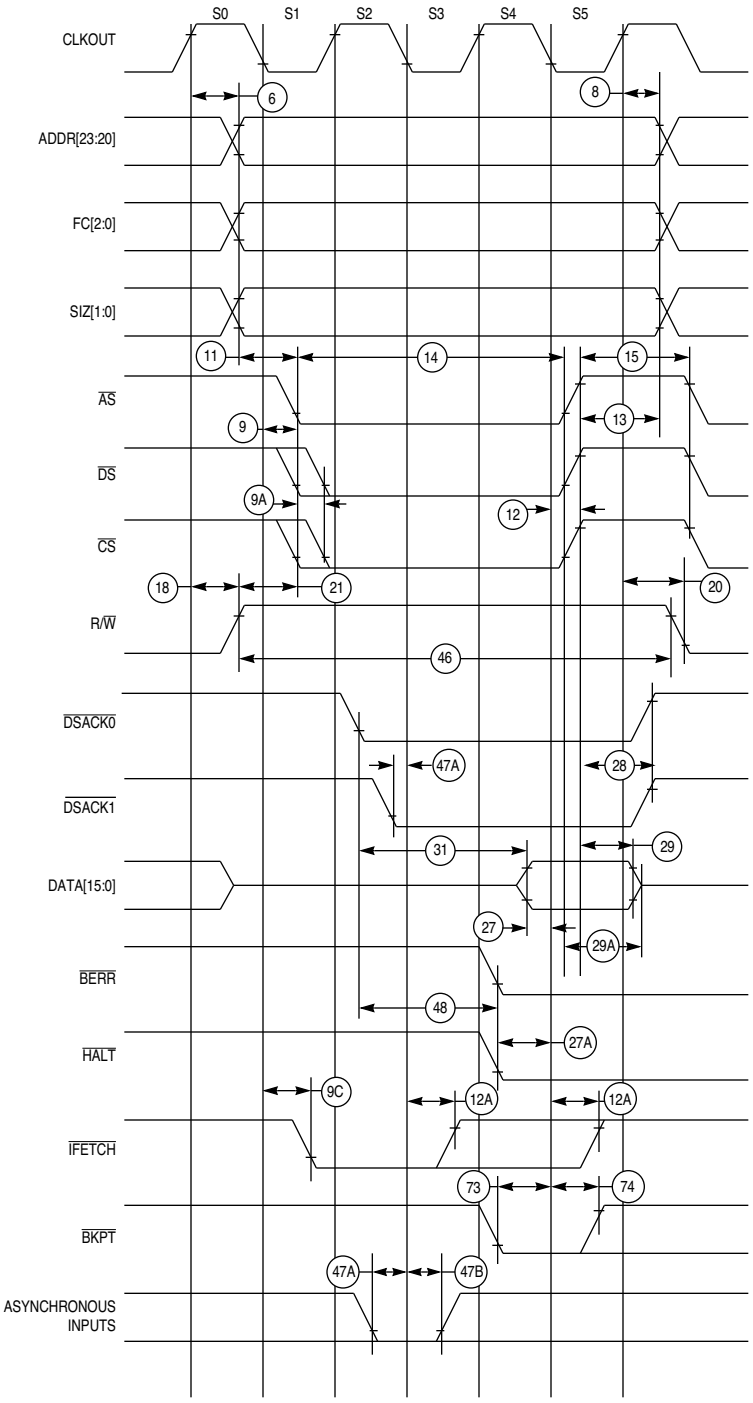


Figure 4 Read Cycle Timing Diagram

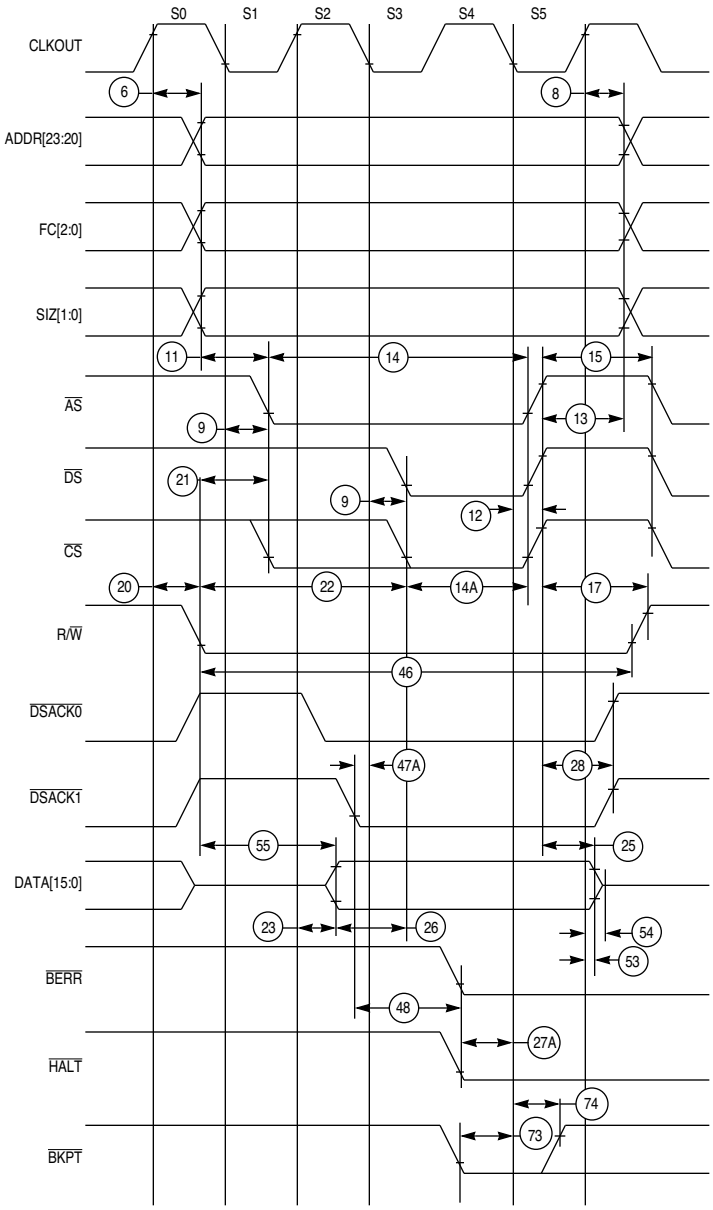


Figure 5 Write Cycle Timing Diagram

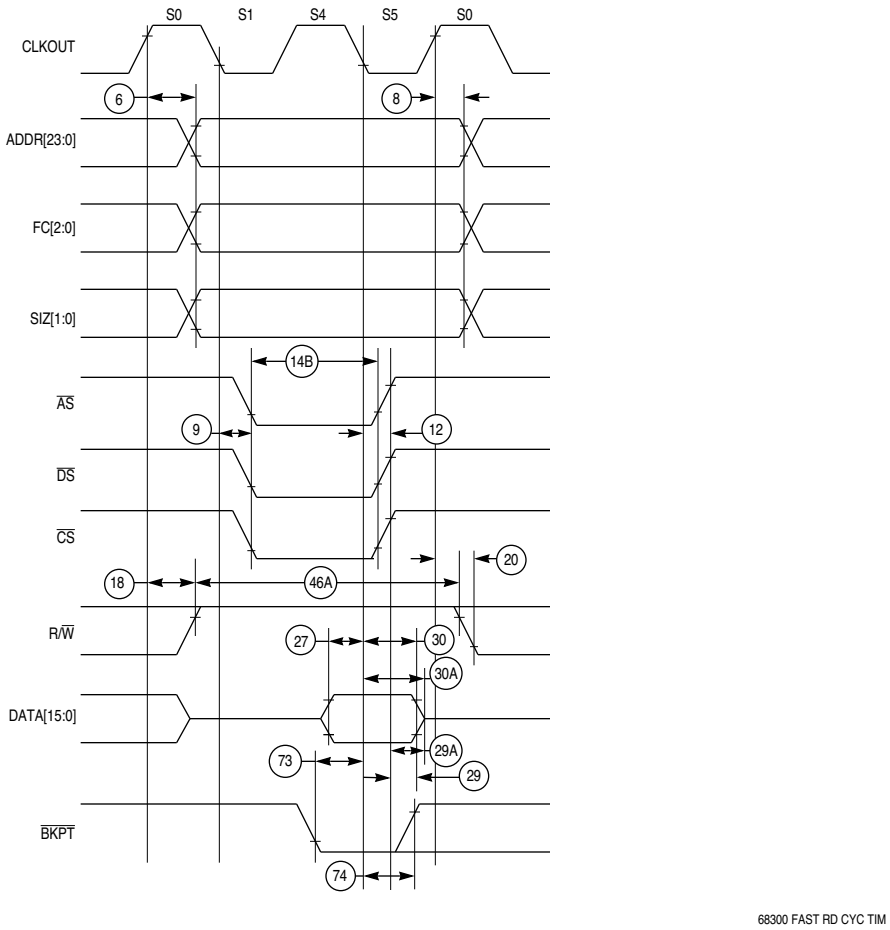


Figure 6 Fast Termination Read Cycle Timing Diagram

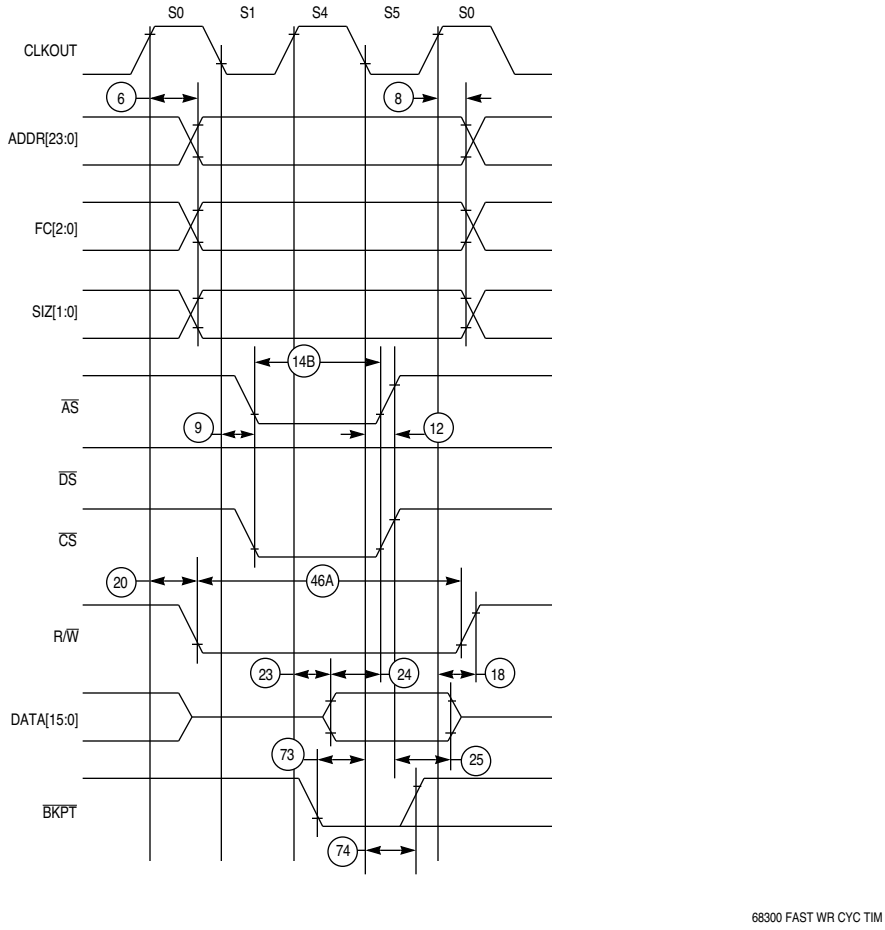


Figure 7 Fast Termination Write Cycle Timing Diagram

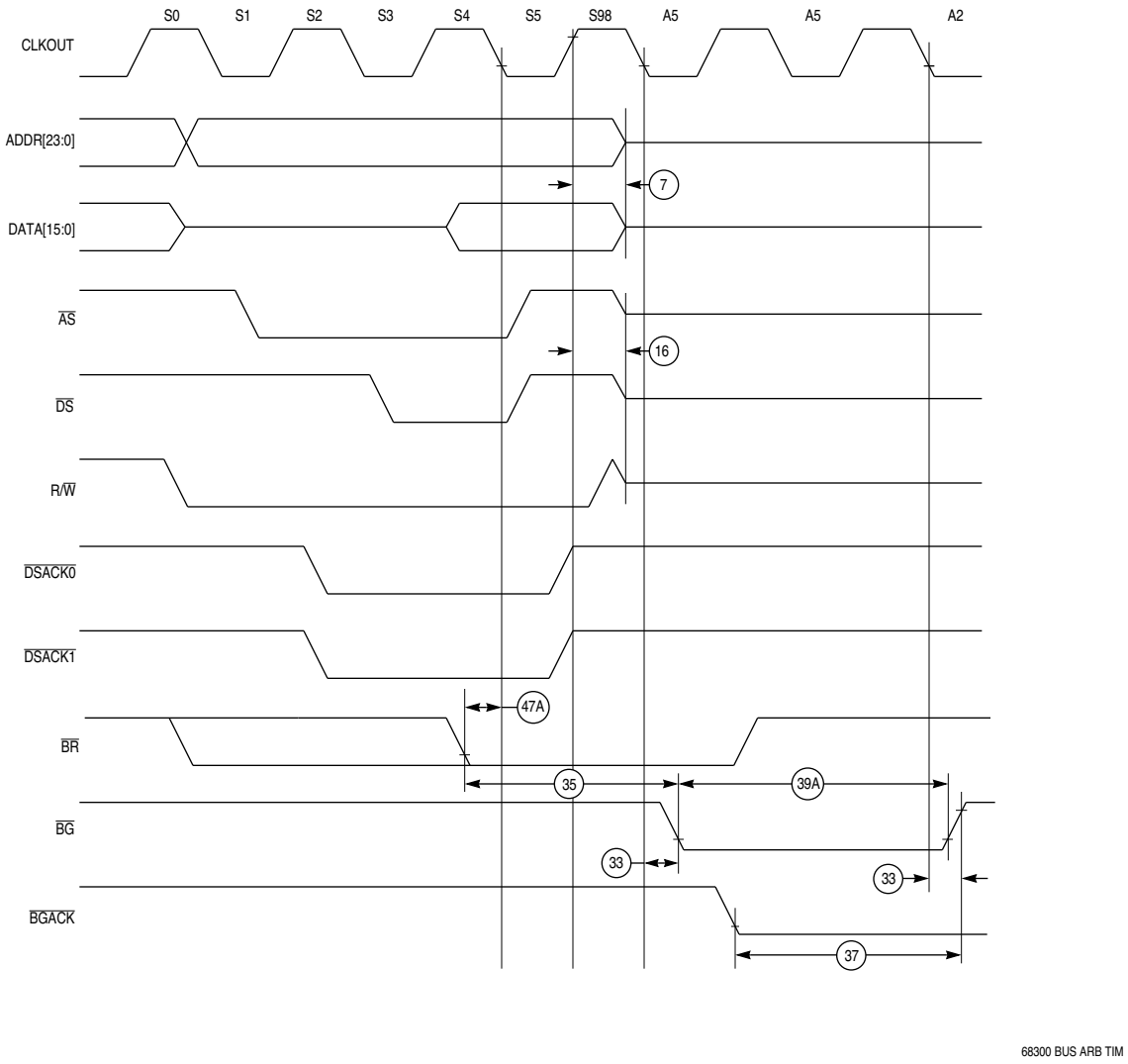


Figure 8 Bus Arbitration Timing Diagram — Active Bus Case

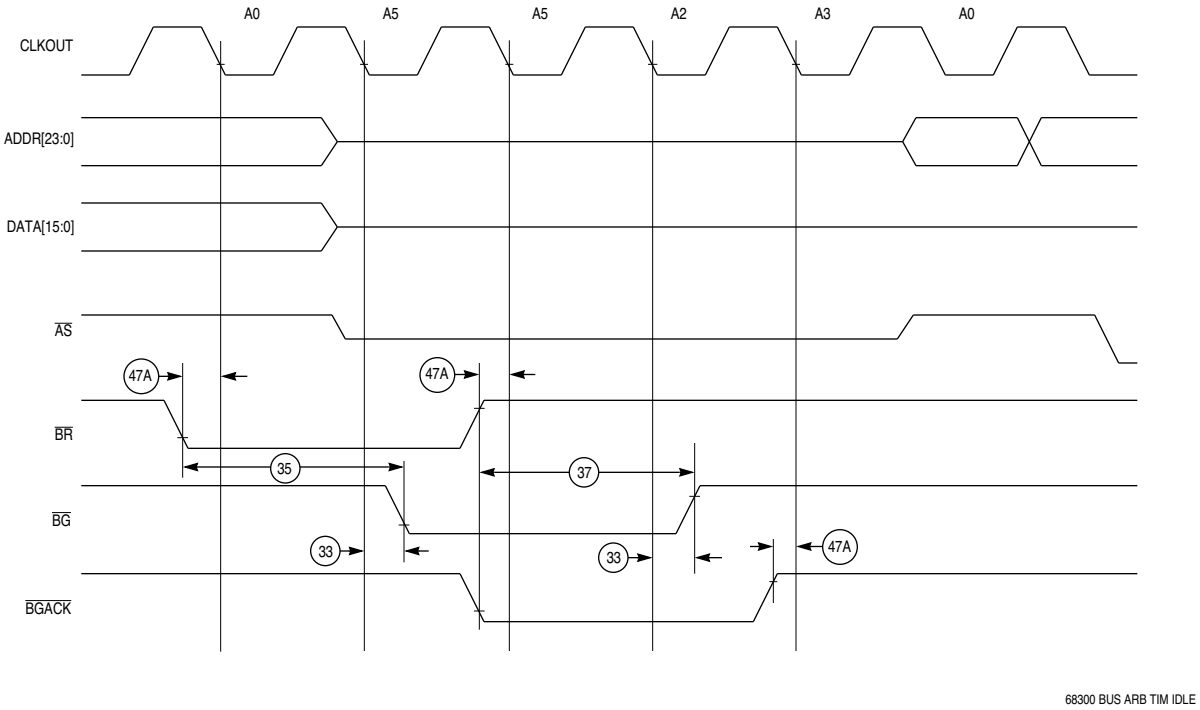
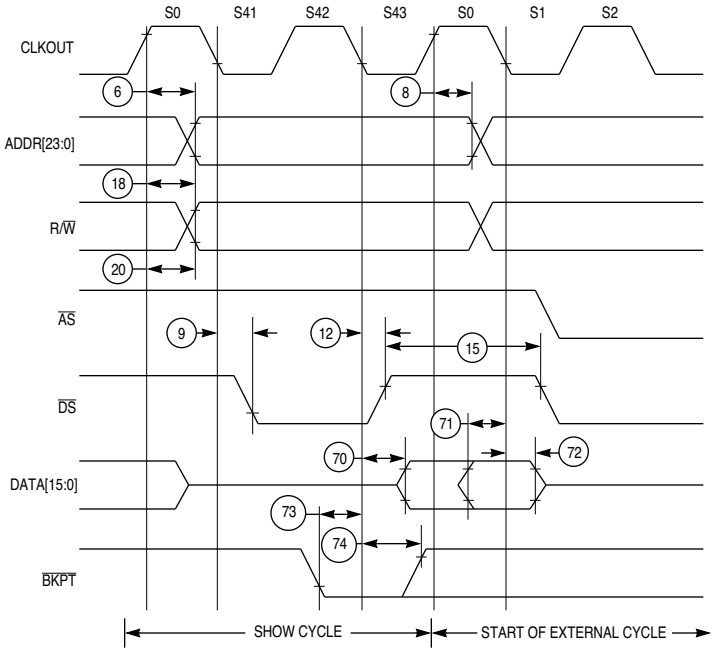


Figure 9 Bus Arbitration Timing Diagram — Idle Bus Case



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

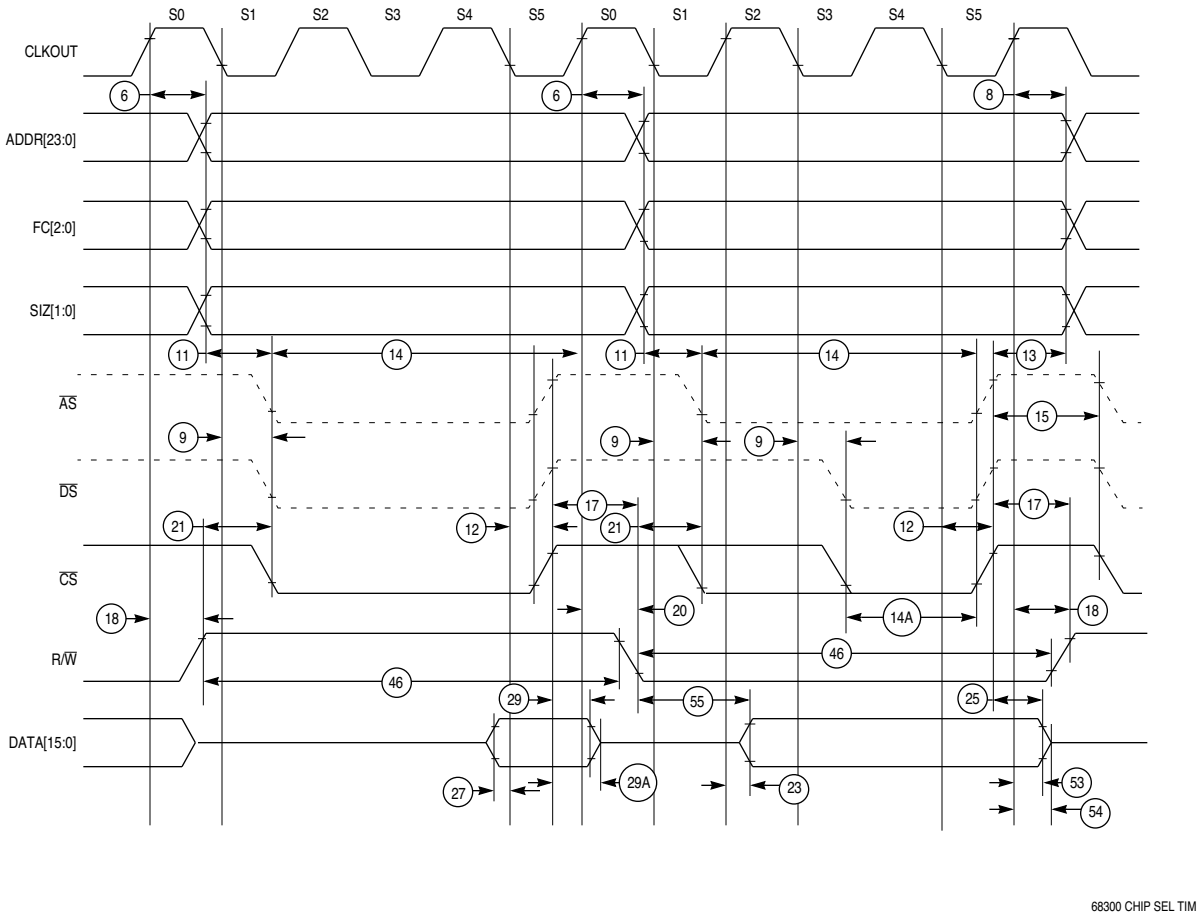


Figure 11 Chip-Select Timing Diagram

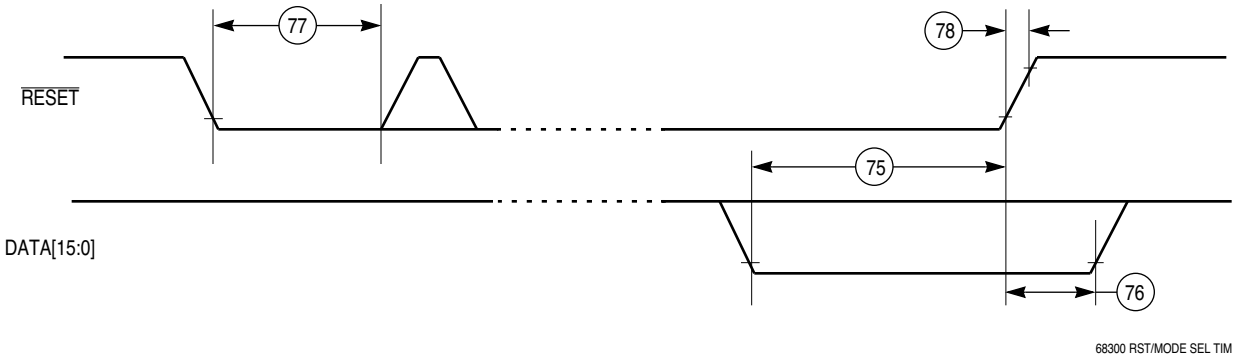


Figure 12 Reset and Mode Select Timing Diagram

Table 7 Background Debugging Mode Timing

(V_{DD} and V_{DDSYN} = 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 $\overline{\text{IFETCH}}$ High Impedance	t_{IPZ}	—	50	ns
B8	CLKOUT High to $\overline{\text{IFETCH}}$ 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.

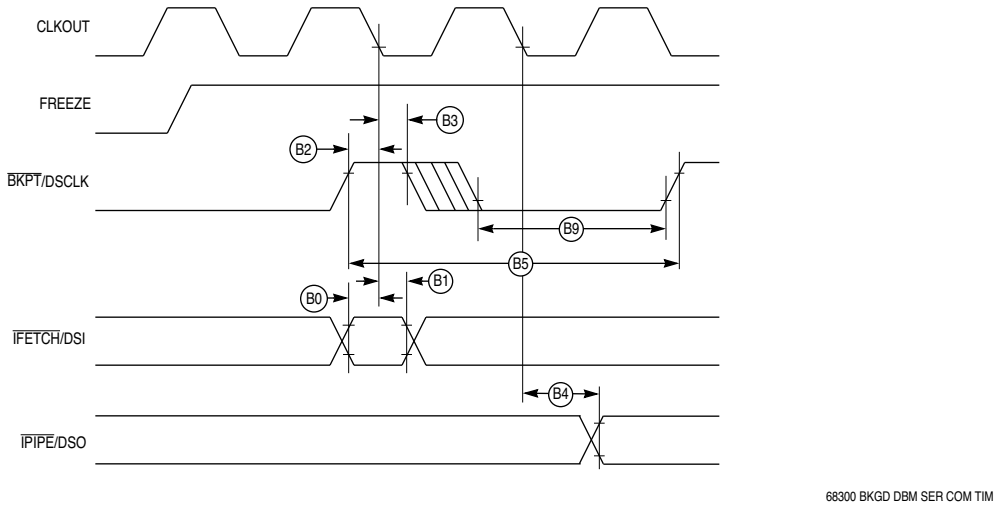


Figure 13 BDM Serial Communication Timing Diagram

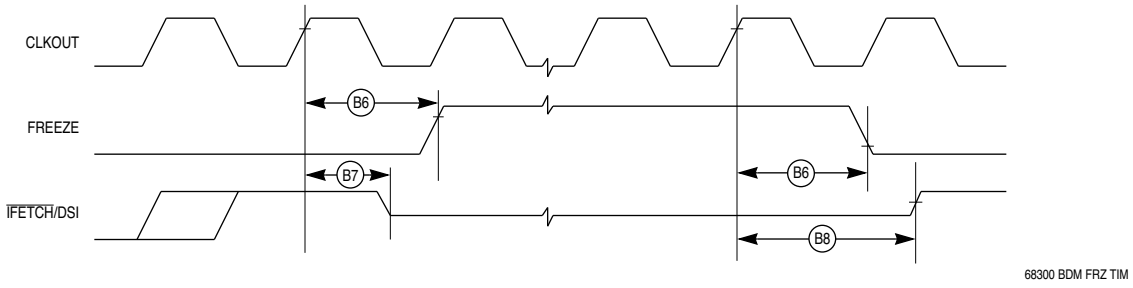


Figure 14 BDM Freeze Assertion Timing Diagram

Table 8 ECLK Bus 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
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_{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)[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 = $t_{Ecyc} - t_{ECSD} - t_{EDSR}$.

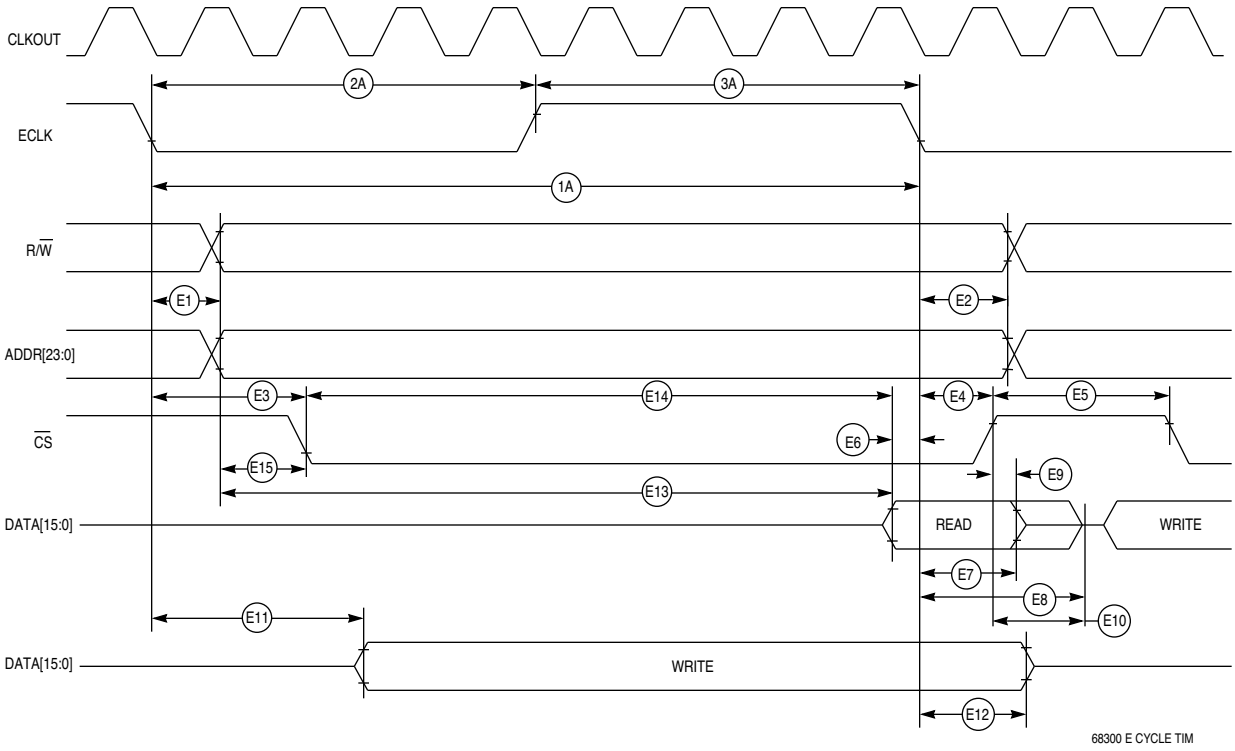


Figure 15 ECLK Timing Diagram

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_{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} – 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.

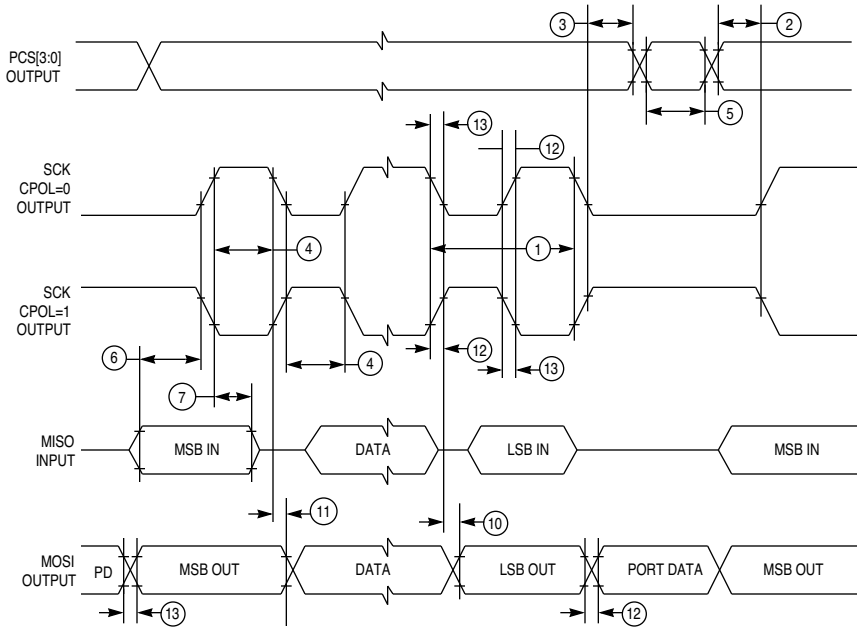


Figure 16 QSPI Timing — Master, CPHA = 0

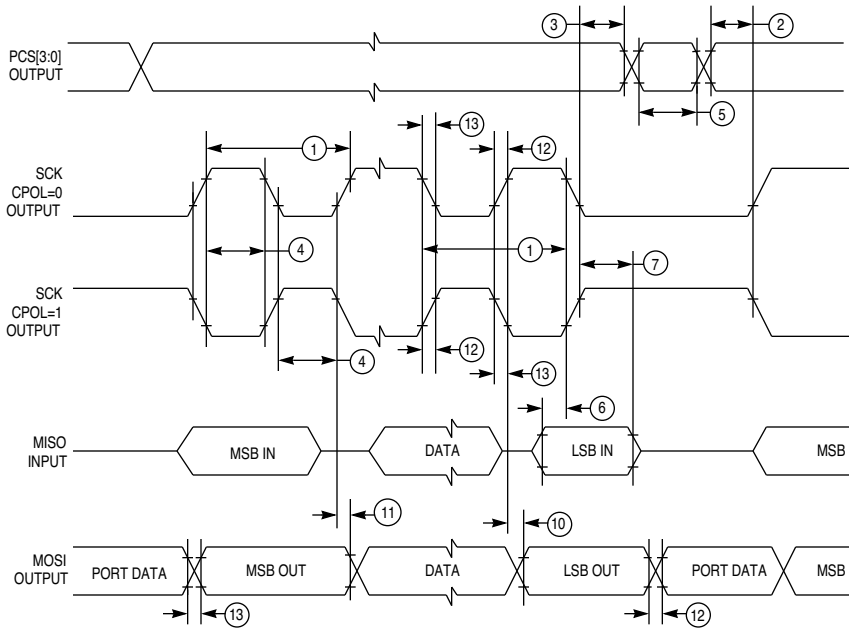


Figure 17 QSPI Timing — Master, CPHA = 1

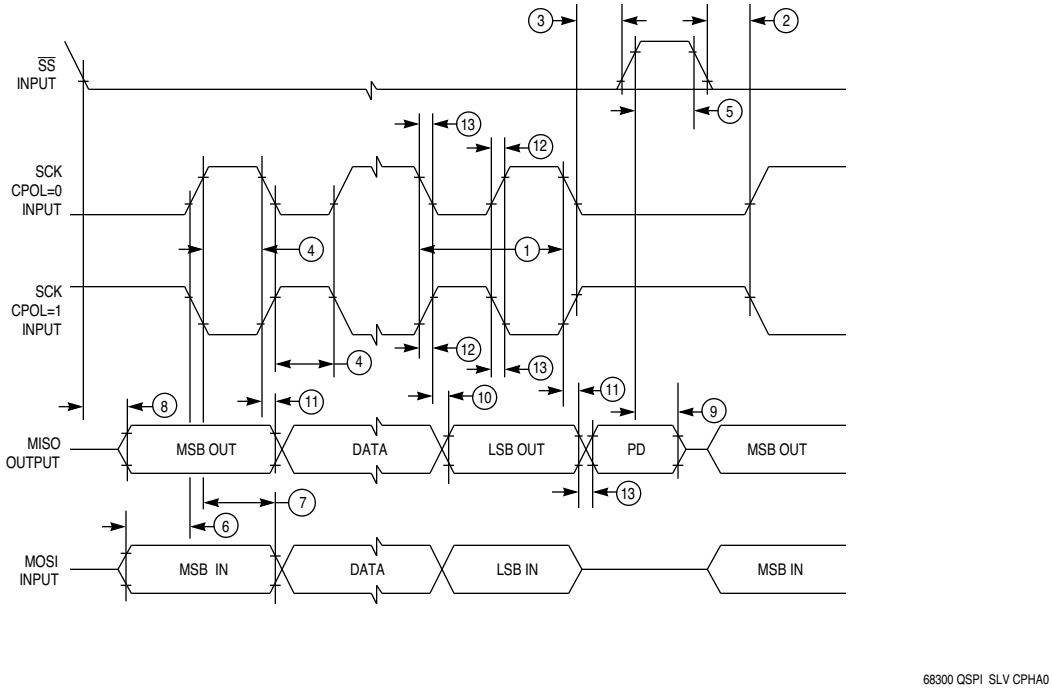


Figure 18 QSPI Timing — Slave, CPHA = 0

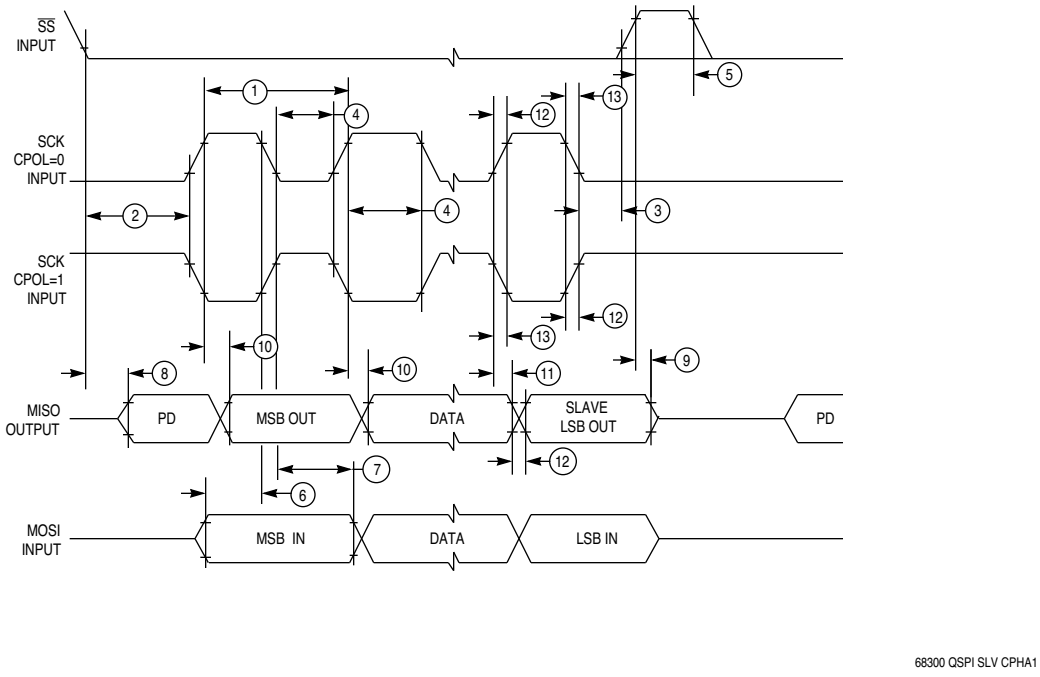
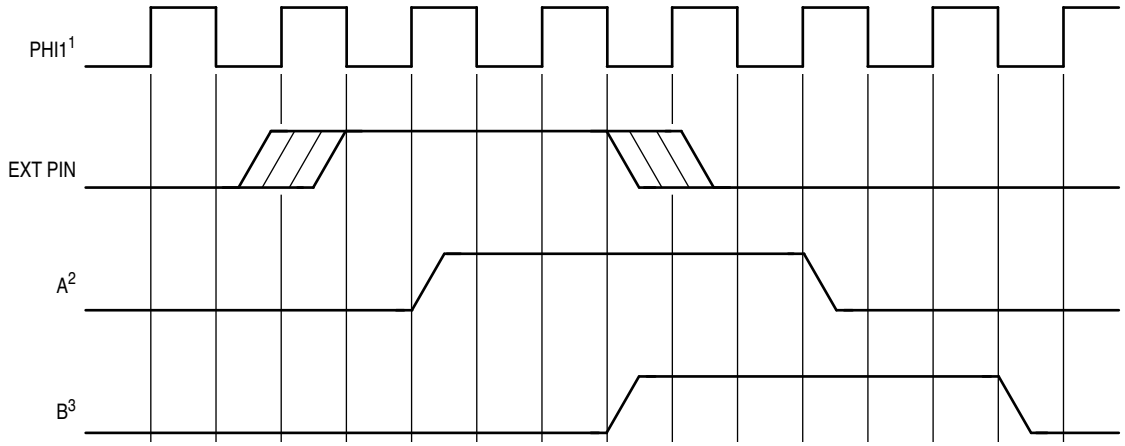


Figure 19 QSPI Timing — Slave, CPHA = 1

Table 10 General-Purpose Timer AC Characteristics

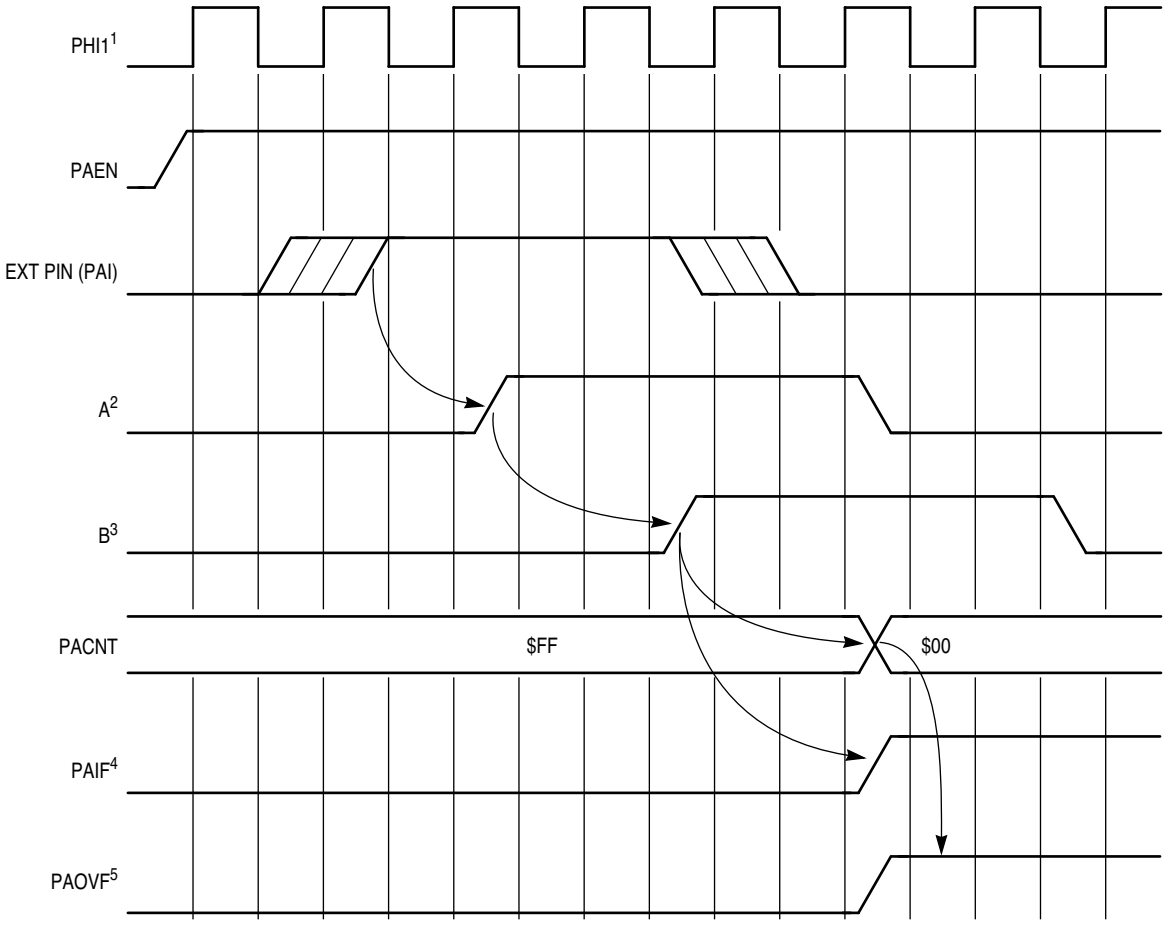
Num	Parameter	Symbol	Min	Max	Unit
1	Operating Frequency	Fclock	0	16.78	MHz
2	PCLK Frequency	Fpclk	0	1/4 Fclock	MHz
3	Pulse Width Input Capture	PWtim	2/Fclock	—	—
4	PWM Resolution	—	2/Fclock	—	—
5	IC/OC Resolution	—	4/Fclock	—	—
6	PCLK Width (PWM)	—	4/Fclock	—	—
7	PCLK Width (IC/OC)	—	4/Fclock	—	—
8	PAI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

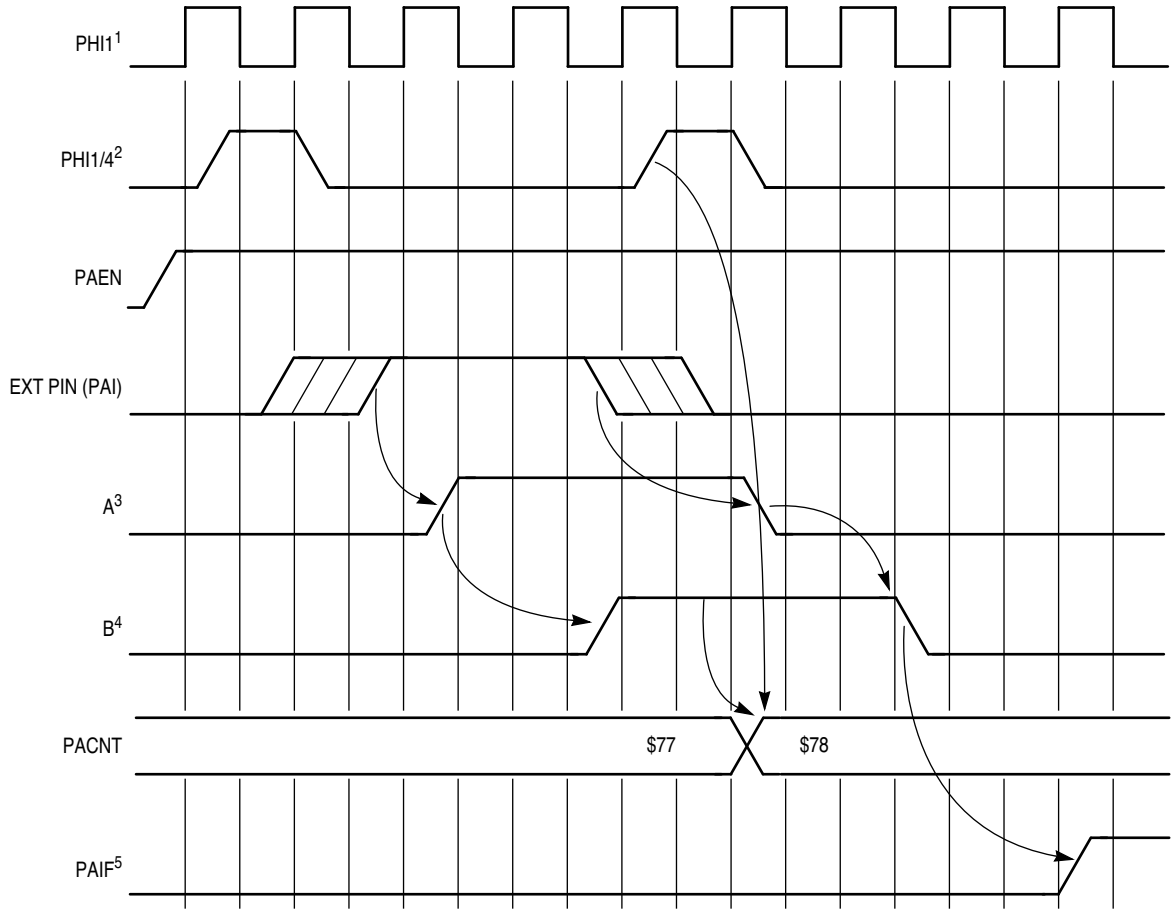
Figure 20 Input Signal Conditioner Timing



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

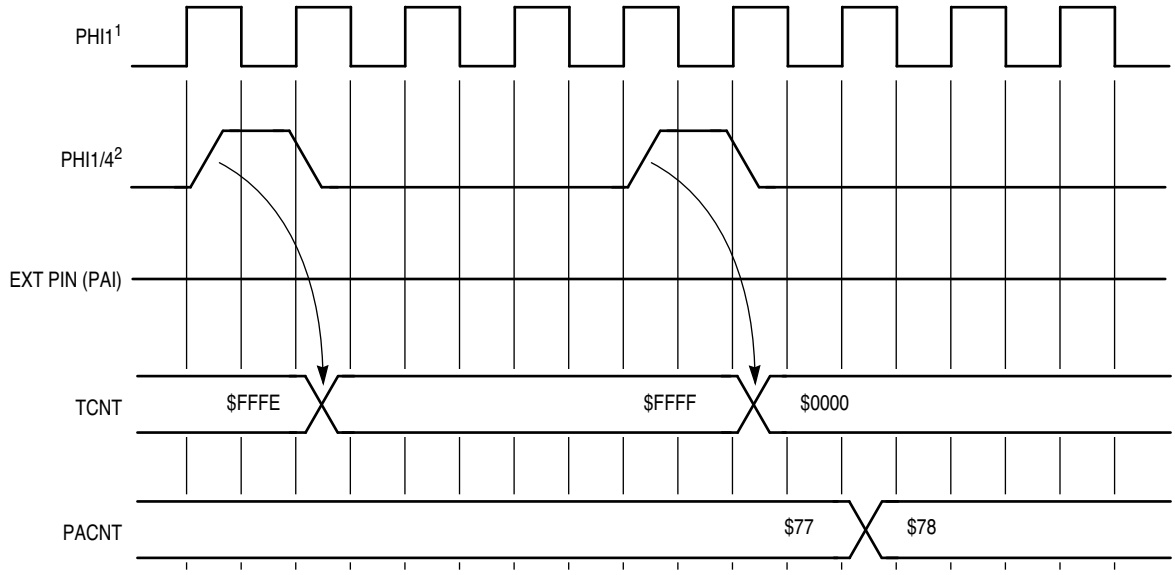
Figure 21 Pulse Accumulator —Event Counting Mode (Leading Edge)



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

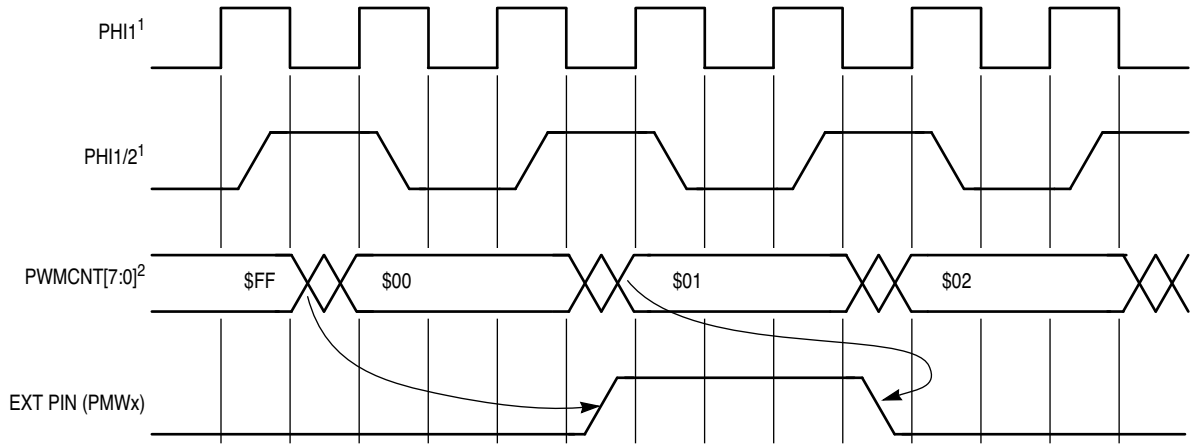
Figure 22 Pulse Accumulator —Gated Mode (Count While Pin High)



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

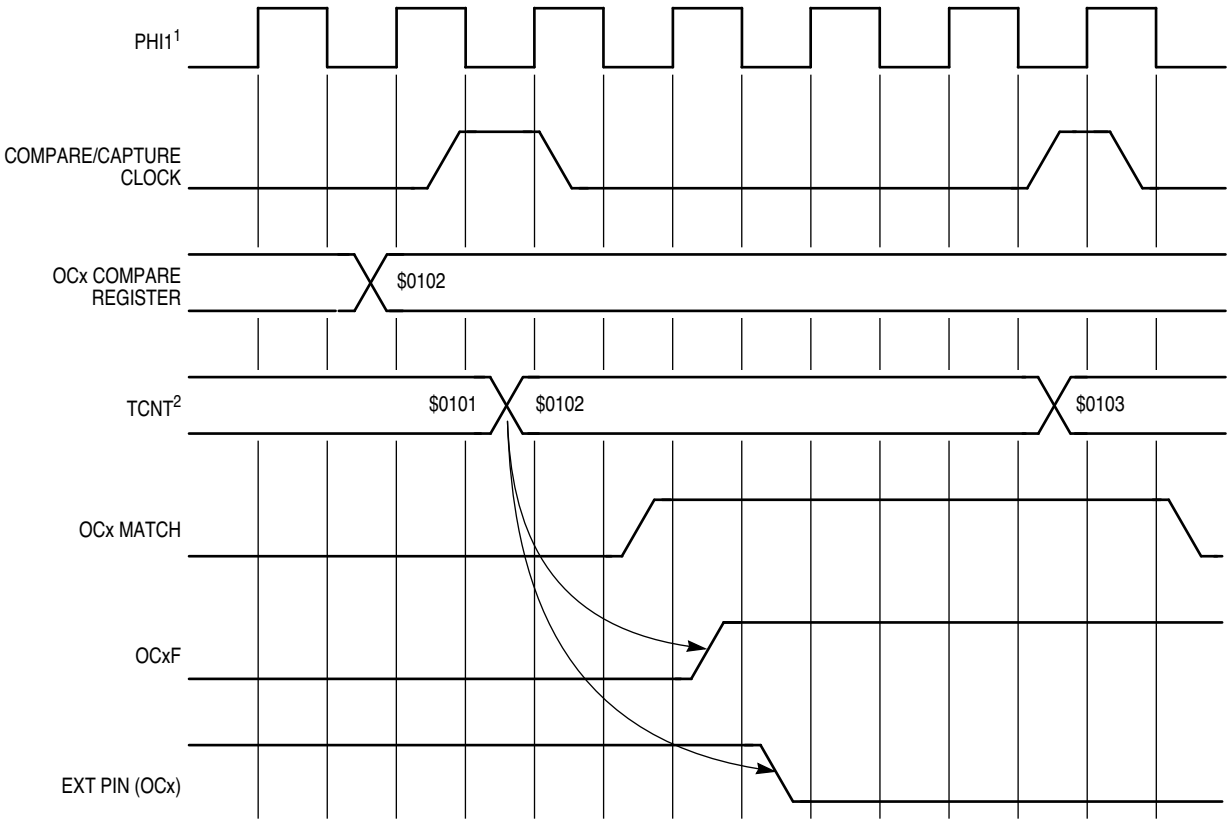
Figure 23 Pulse Accumulator —Using TOF as Gated Mode Clock



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

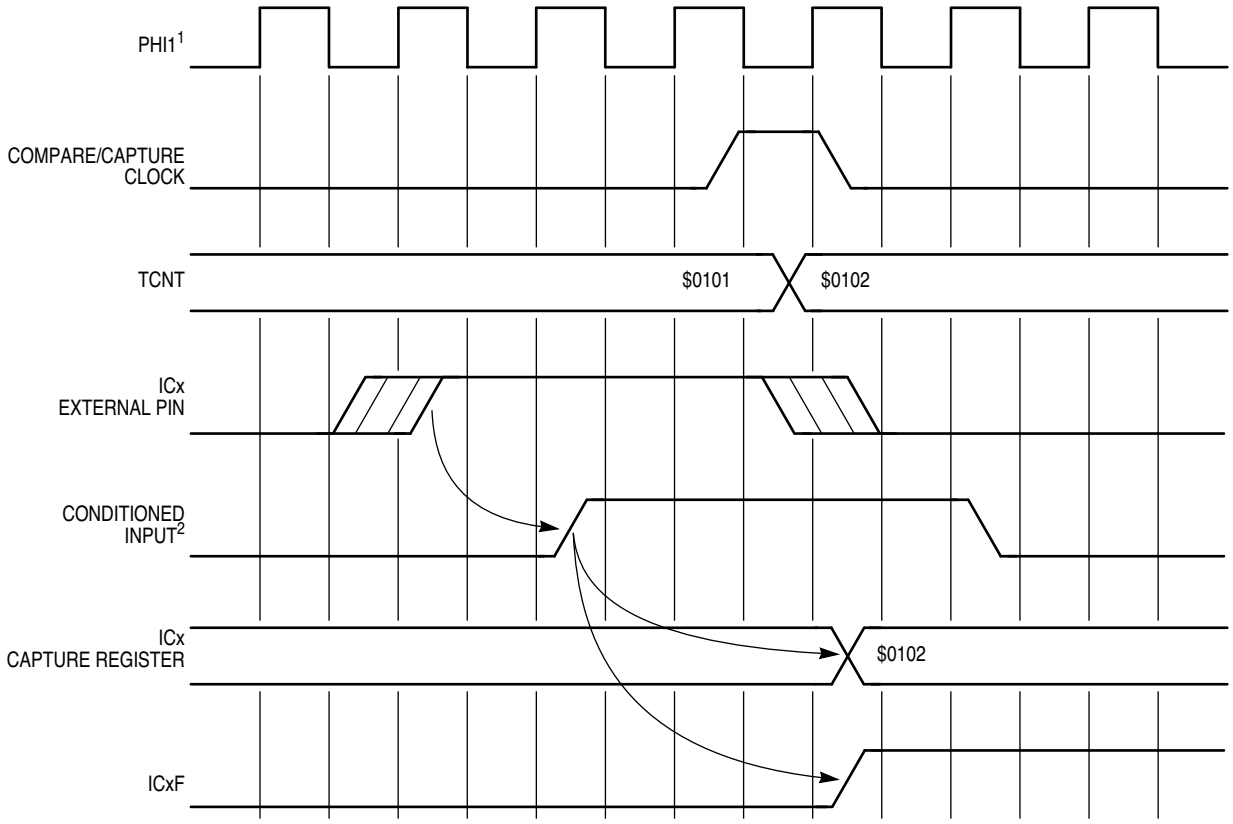
Figure 24 PWMx (PWMx Register = 01, Fast Mode)



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

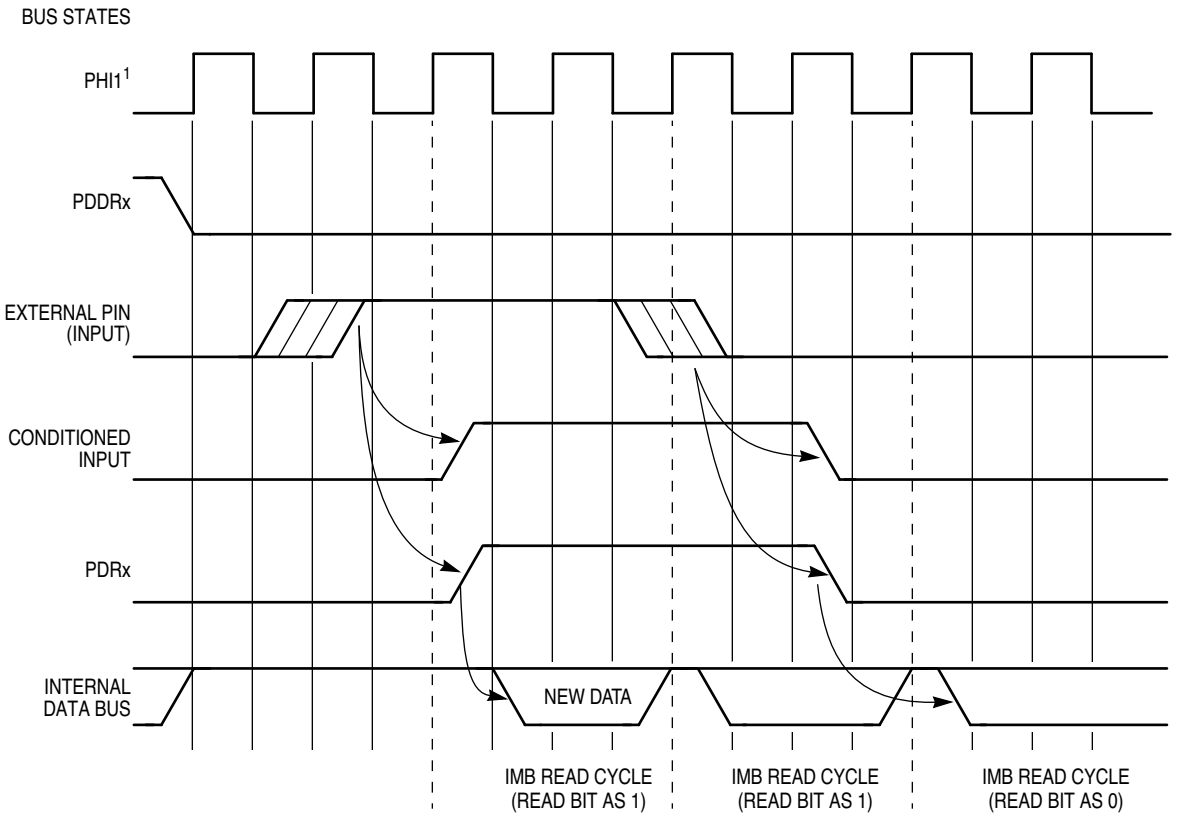
Figure 25 Output Compare (Toggle Pin State)



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

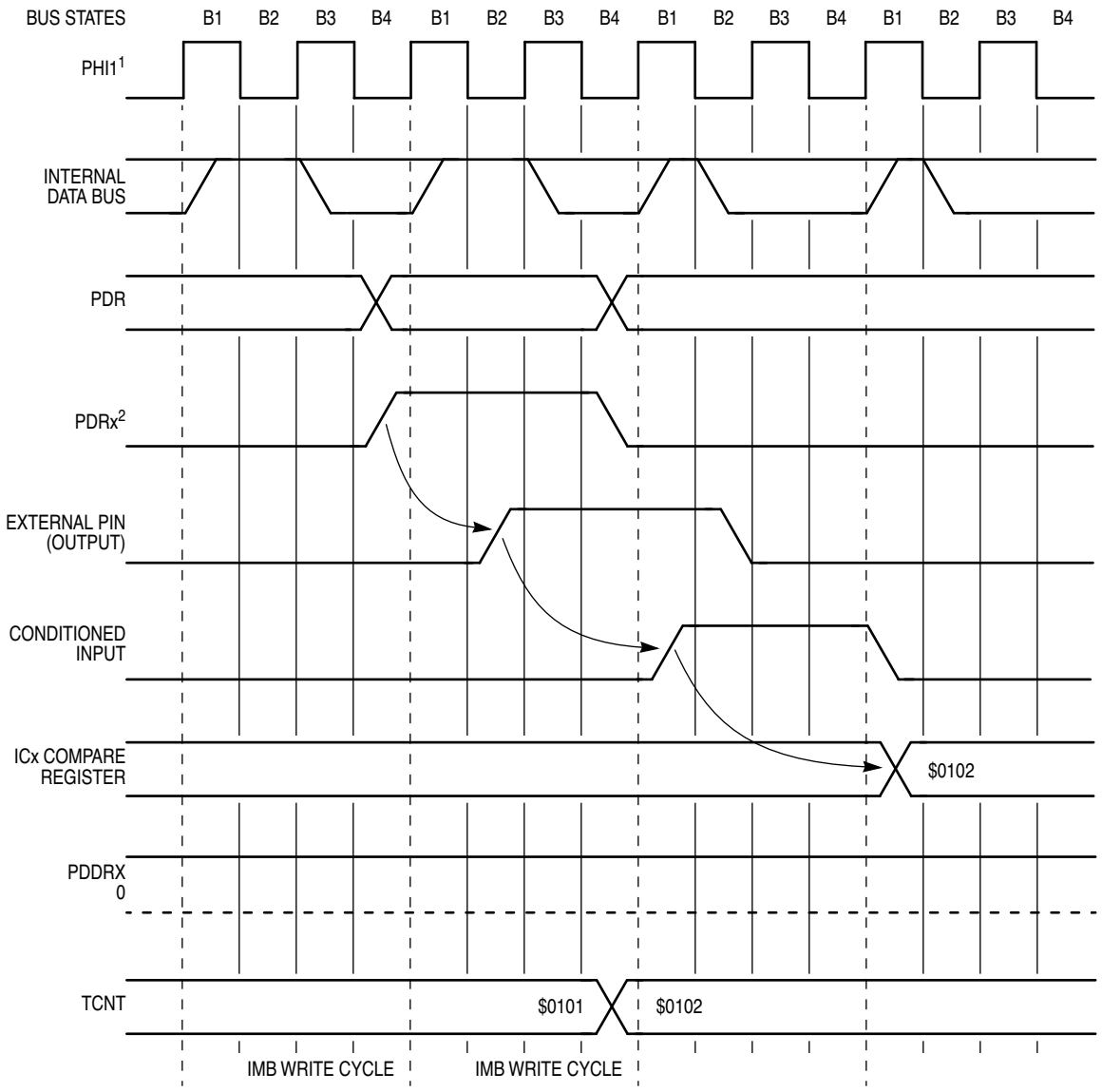
Figure 26 Input Capture (Capture on Rising Edge



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

GENERAL PURPOSE INPUT

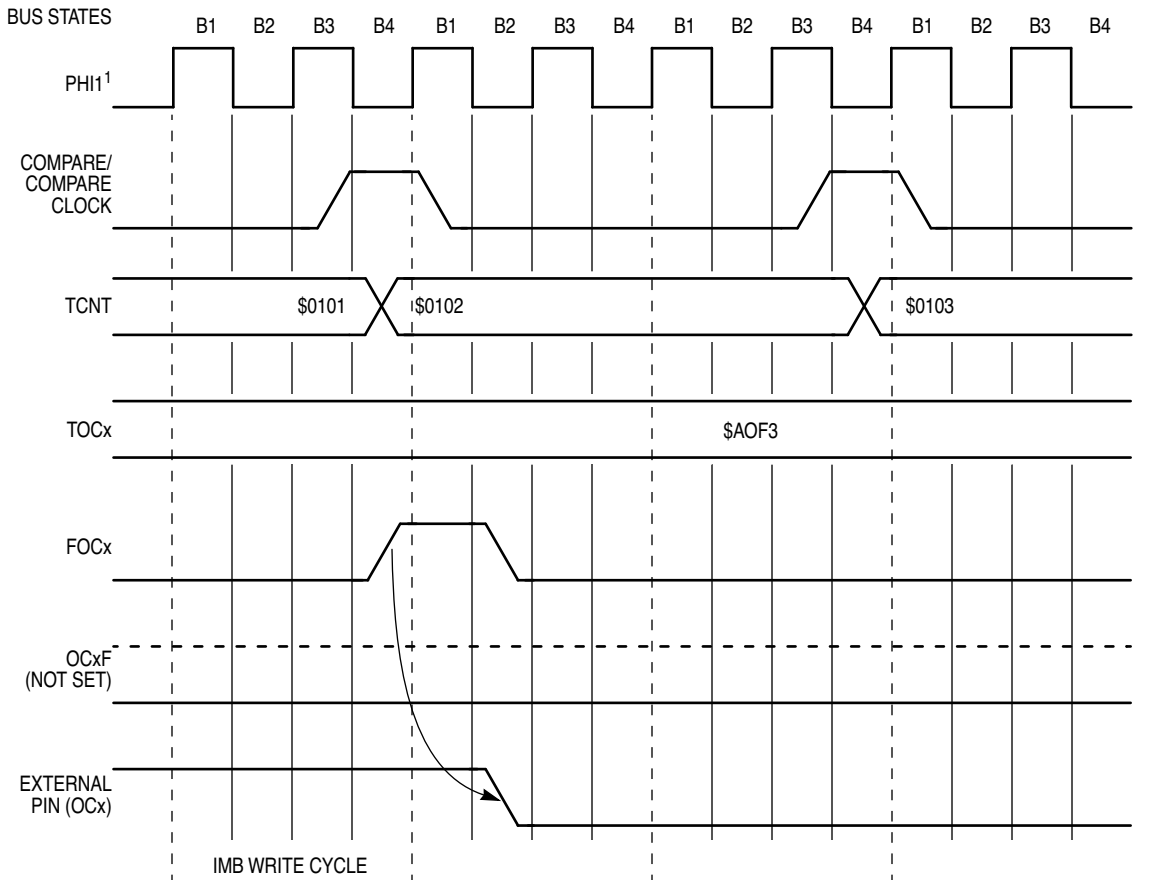
Figure 27 General-Purpose Input



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)

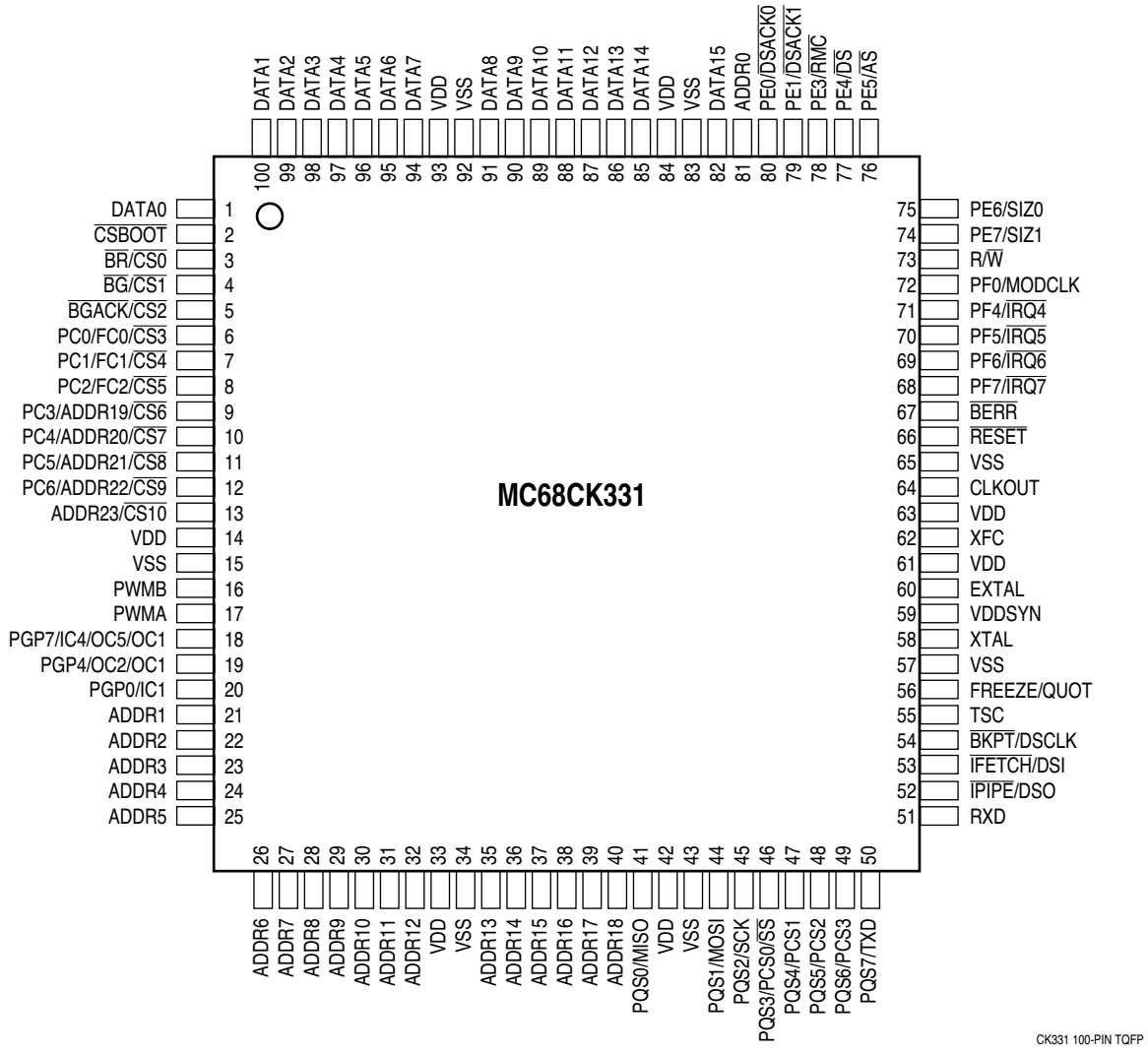


Figure 30 MC68CK331 Pin Assignments for 100-Pin Package

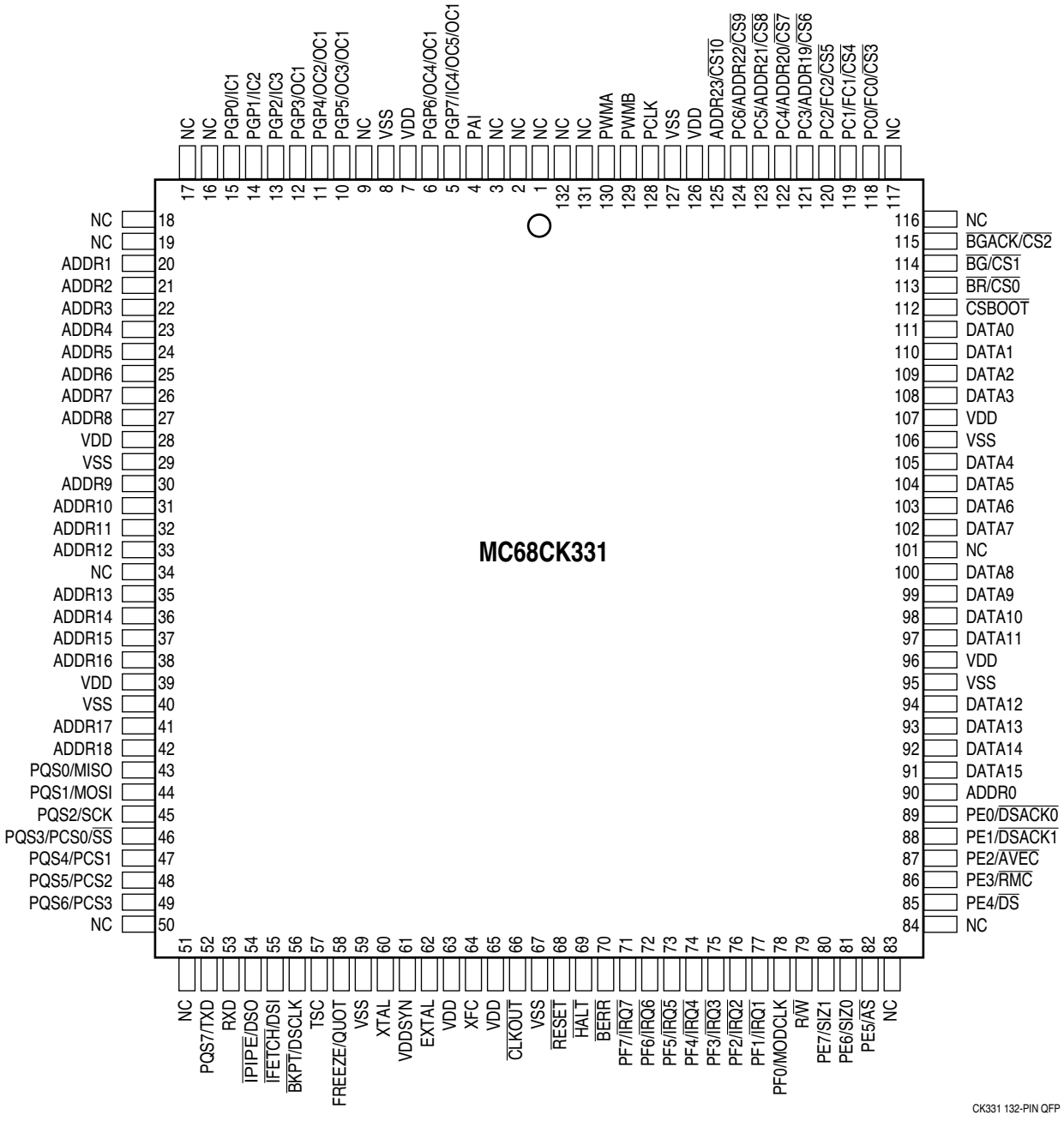


Figure 31 MC68CK331 Pin Assignments for 132-Pin Package

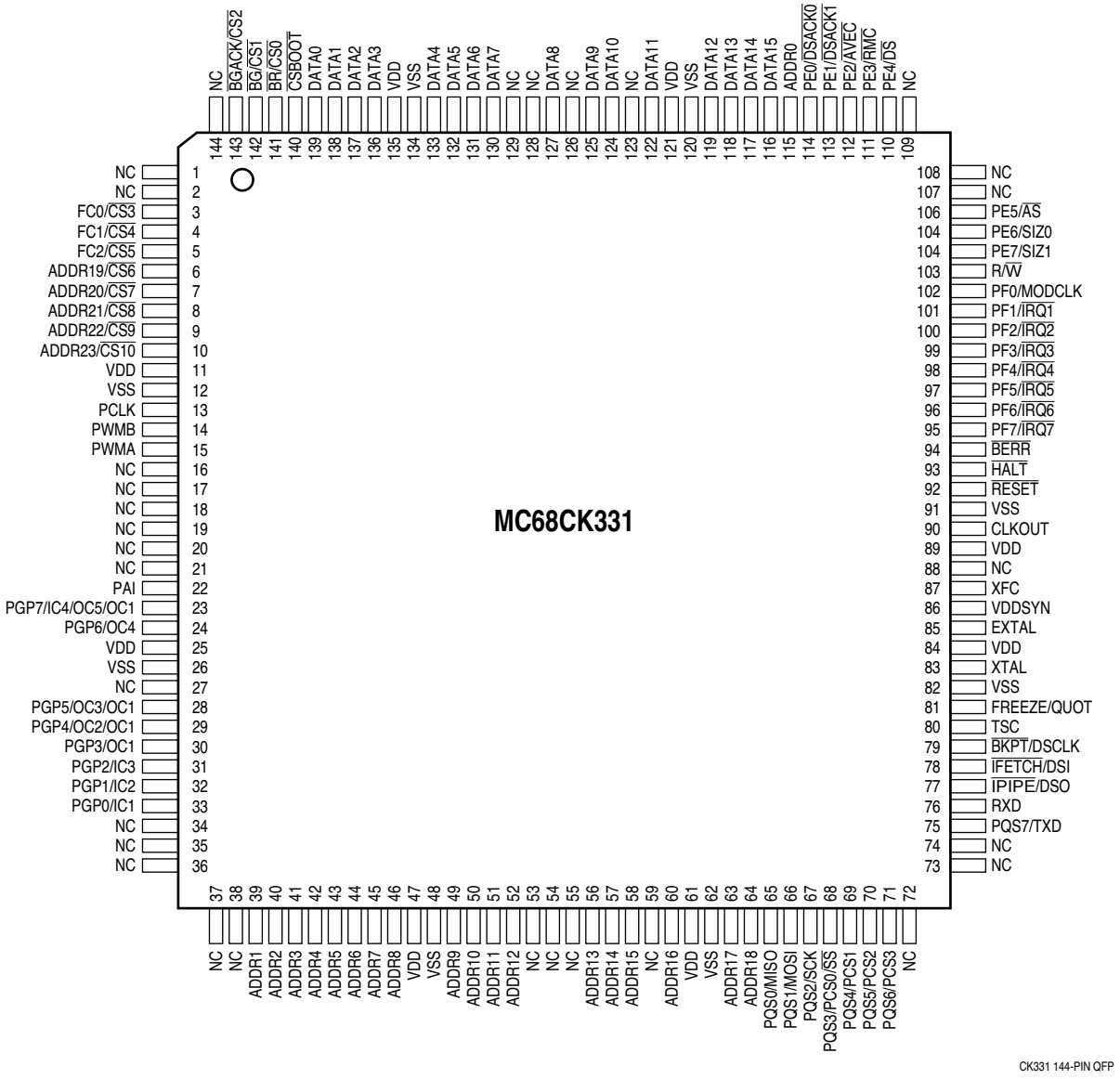


Figure 32 MC68CK331 Pin Assignments for 144-Pin Package

Table 11 MC68CK331PU 100-Pin TQFP Pin Assignments

Pin	Description	Pin	Description	Pin	Description	Pin	Description
1	DATA0	26	ADDR6	51	RXD	76	PE5/$\overline{AS}$
2	$\overline{CSBOOT}$	27	ADDR7	52	$\overline{IPIPE}$/DSO	77	PE4/$\overline{DS}$
3	$\overline{BR}$/$\overline{CS0}$	28	ADDR8	53	$\overline{IFETCH}$/DSI	78	PE3/$\overline{RMC}$
4	$\overline{BG}$/$\overline{CS0}$	29	ADDR9	54	$\overline{BKPT}$/DSCLK	79	PE1/$\overline{DSACK1}$
5	$\overline{BGACK}$/$\overline{CS2}$	30	ADDR10	55	TSC	80	PE0/$\overline{DSACK0}$
6	PC0/FC0/$\overline{CS3}$	31	ADDR11	56	FREEZE/QUOT	81	ADDR0
7	PC1/FC1/$\overline{CS4}$	32	ADDR12	57	V_{SS}	82	DATA15
8	PC2/FC2/$\overline{CS5}$	33	V_{DD}	58	V_{DD}	83	V_{SS}
9	PC3/ADDR19/$\overline{CS6}$	34	V_{SS}	59	V_{DDSYN}	84	V_{DD}
10	PC4/ADDR20/$\overline{CS7}$	35	ADDR13	60	EXTAL	85	DATA14
11	PC5/ADDR21/$\overline{CS8}$	36	ADDR14	61	V_{DD}	86	DATA13
12	PC6/ADDR22/$\overline{CS9}$	37	ADDR15	62	XFC	87	DATA12
13	ADDR23/$\overline{CS10}$	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	$\overline{RESET}$	91	DATA8
17	PWMA	42	VDD	67	$\overline{BERR}$	92	V_{SS}
18	PGP7/IC4/OC5/OC1	43	VSS	68	PF7/$\overline{IRQ7}$	93	V_{DD}
19	PGP4/OC2/OC1	44	PQS1/MOSI	69	PF6/$\overline{IRQ6}$	94	DATA7
20	PGP0/IC1	45	PQS2/SCK	70	PF5/$\overline{IRQ5}$	95	DATA6
21	ADDR1	46	PQS3/PCS0/$\overline{SS}$	71	PF4/$\overline{IRQ4}$	96	DATA5
22	ADDR2	47	PQS4/PCS1	72	PF0/MODCLK	97	DATA4
23	ADDR3	48	PQS5/PCS2	73	R/$\overline{W}$	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	$\overline{HALT}$	High	Single-step, double bus fault
	PE2/$\overline{AVEC}$	High	Must use chip-select for $\overline{AVEC}$
	PF3/$\overline{IRQ3}$	High	Level 3 interrupt request, port pin
	PF2/$\overline{IRQ2}$	High	Level 2 interrupt request, port pin
	PF1/$\overline{IRQ1}$	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

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