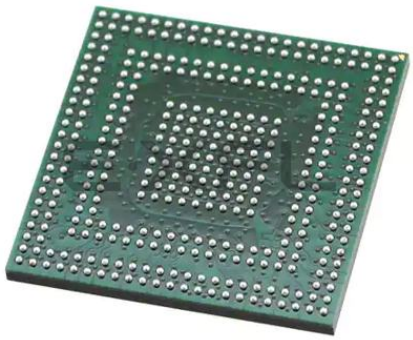

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Understanding Embedded - Microprocessors

Embedded microprocessors are specialized computing chips designed to perform specific tasks within an embedded system. Unlike general-purpose microprocessors found in personal computers, embedded microprocessors are tailored for dedicated functions within larger systems, offering optimized performance, efficiency, and reliability. These microprocessors are integral to the operation of countless electronic devices, providing the computational power necessary for controlling processes, handling data, and managing communications.

Applications of Embedded - Microprocessors

Embedded microprocessors are utilized across a broad spectrum of applications, making them indispensable in

Details	
Product Status	Obsolete
Core Processor	PowerPC e300c3
Number of Cores/Bus Width	1 Core, 32-Bit
Speed	266MHz
Co-Processors/DSP	Communications; QUICC Engine
RAM Controllers	DDR2
Graphics Acceleration	No
Display & Interface Controllers	-
Ethernet	10/100Mbps (3)
SATA	-
USB	USB 2.0 (1)
Voltage - I/O	1.8V, 3.3V
Operating Temperature	-40°C ~ 105°C (TA)
Security Features	-
Package / Case	369-LFBGA
Supplier Device Package	369-PBGA (19x19)
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/ppc8309cvmaddca

4.2 AC electrical characteristics

The primary clock source for the MPC8309 can be one of two inputs, SYS_CLK_IN or PCI_SYNC_IN, depending on whether the device is configured in PCI host or agent mode. The following table provides the clock input (SYS_CLK_IN/PCI_SYNC_IN) AC timing specifications for the MPC8309. These specifications are also applicable for QE_CLK_IN.

Table 8. SYS_CLK_IN AC timing specifications

Parameter/Condition	Symbol	Min	Typical	Max	Unit	Note
SYS_CLK_IN frequency	$f_{SYS\_CLK\_IN}$	24 —		66.67	MHz	1
SYS_CLK_IN cycle time	$t_{SYS\_CLK\_IN}$	15	—	41.6	ns	—
SYS_CLK_IN rise and fall time	t_{KH}, t_{KL}	1.1	—	2.8	ns	2
PCI_SYNC_IN rise and fall time	t_{PCH}, t_{PCL}	1.1	—	2.8	ns	2
SYS_CLK_IN duty cycle	$t_{KHK}/t_{SYS\_CLK\_IN}$	40	—	60	%	3
SYS_CLK_IN jitter	—	—	—	±150	ps	4, 5

Notes:
1. **Caution:** The system, core and QUICC Engine block must not exceed their respective maximum or minimum operating frequencies.
2. Rise and fall times for SYS_CLK_IN are measured at 0.33 and 2.97 V.
3. Timing is guaranteed by design and characterization.
4. This represents the total input jitter—short term and long term—and is guaranteed by design.
5. The SYS_CLK_IN driver's closed loop jitter bandwidth should be < 500 kHz at –20 dB. The bandwidth must be set low to allow cascade-connected PLL-based devices to track SYS_CLK_IN drivers with the specified jitter.
6. Spread spectrum is allowed up to 1% down-spread @ 33kHz (max rate).

5 RESET initialization

This section describes the AC electrical specifications for the reset initialization timing requirements of the MPC8309. The following table provides the reset initialization AC timing specifications for the reset component(s).

Table 9. RESET initialization timing specifications

Parameter/Condition	Min	Max	Unit	Note
Required assertion time of $\overline{\text{HRESET}}$ to activate reset flow	32	—	$t_{SYS\_CLK\_IN}$	1
Required assertion time of PORESET with stable clock applied to SYS_CLK_IN or PCI_SYNC_IN (in agent mode)	32	—	$t_{SYS\_CLK\_IN}$	1
$\overline{\text{HRESET}}$ assertion (output)	512	—	$t_{SYS\_CLK\_IN}$	1

Table 9. RESET initialization timing specifications (continued)

Input setup time for POR configuration signals (CFG_RESET_SOURCE[0:3]) with respect to negation of $\overline{\text{PORESET}}$	4	—	$t_{SYS\_CLK\_IN}$	1, 2
Input hold time for POR config signals with respect to negation of $\overline{\text{HRESET}}$	0	—	ns	1, 2

Notes:
1. $t_{SYS\_CLK\_IN}$ is the clock period of the input clock applied to SYS_CLK_IN. For more details, see the *MPC8309 PowerQUICC II Pro Integrated Communications Processor Family Reference Manual*.
2. POR configuration signals consist of CFG_RESET_SOURCE[0:3].

The following table provides the PLL lock times.

Table 10. PLL lock times

Parameter/Condition	Min	Max	Unit	Note
PLL lock times	—	100	µs	—

5.1 Reset signals DC electrical characteristics

The following table provides the DC electrical characteristics for the MPC8309 reset signals mentioned in Table 9.

Table 11. Reset signals DC electrical characteristics

Characteristic	Symbol	Condition	Min	Max	Unit	Note
Output high voltage	V_{OH}	I_{OH} = –6.0 mA	2.4	—	V	1
Output low voltage	V_{OL}	I_{OL} = 6.0 mA	—	0.5	V	1
Output low voltage	V_{OL}	I_{OL} = 3.2 mA	—	0.4	V	1
Input high voltage	V_{IH}	—	2.0	OV_{DD} + 0.3	V	1
Input low voltage	V_{IL}	—	–0.3	0.8	V	—
Input current	I_{IN}	$0 V \le V_{IN} \le OV_{DD}$	— ±	5	µA	—

Note:
1. This specification applies when operating from 3.3 V supply.

6 DDR2 SDRAM

This section describes the DC and AC electrical specifications for the DDR2 SDRAM interface of the MPC8309. Note that DDR2 SDRAM is GV_{DD}(typ) = 1.8 V.

6.1 DDR2 SDRAM DC electrical characteristics

The following table provides the recommended operating conditions for the DDR2 SDRAM component(s) of the MPC8309 when GV_{DD}(typ) = 1.8 V.

The following table provides the DDR2 capacitance when GV_{DD}(typ) = 1.8 V.

Table 16. DDR2 SDRAM output AC timing specifications (continued)

At recommended operating conditions with GV_{DD} of 1.8V ± 100mV.

Parameter	Symbol[1]	Min	Max	Unit	Note
$\overline{MCS}$ output setup with respect to MCK 333 MHz 266 MHz	t_{DDKHCS}	 2.4 2.5	 — 	ns	3
$\overline{MCS}$ output hold with respect to MCK 333 MHz 266 MHz	t_{DDKHCX}	 2.4 2.5	 — 	ns	3
MCK to MDQS Skew	t_{DDKHMH}	–0.6	0.6	ns	4
MDQ/MDM output setup with respect to MDQS 333 MHz 266 MHz	t_{DDKHDS}, t_{DDKLDS}	 0.8 0.9	 — 	ns	5
MDQ/MDM output hold with respect to MDQS 333 MHz 266 MHz	t_{DDKHDX}, t_{DDKLDX}	 900 1100	 — 	ps	5
MDQS preamble start	t_{DDKHMP}	0.75 x t_{MCK}	—	ns	6
MDQS epilogue end	t_{DDKHME}	0.4 x t_{MCK}	0.6 x t_{MCK}	ns	6

Notes:

1. The symbols used for timing specifications follow the pattern of $t_{\text{(first two letters of functional block)(signal)(state)(reference)(state)}}$ for inputs and $t_{\text{(first two letters of functional block)(reference)(state)(signal)(state)}}$ for outputs. Output hold time can be read as DDR timing (DD) from the rising or falling edge of the reference clock (KH or KL) until the output went invalid (AX or DX). For example, t_{DDKHAS} symbolizes DDR timing (DD) for the time t_{MCK} memory clock reference (K) goes from the high (H) state until outputs (A) are setup (S) or output valid time. Also, t_{DDKLDX} symbolizes DDR timing (DD) for the time t_{MCK} memory clock reference (K) goes low (L) until data outputs (D) are invalid (X) or data output hold time.
2. All MCK/$\overline{MCK}$ referenced measurements are made from the crossing of the two signals ±0.1 V.
3. ADDR/CMD includes all DDR SDRAM output signals except MCK/$\overline{MCK}$, $\overline{MCS}$, and MDQ/MDM/MDQS. For the ADDR/CMD setup and hold specifications, it is assumed that the Clock Control register is set to adjust the memory clocks by 1/2 applied cycle.
4. Note that t_{DDKHMH} follows the symbol conventions described in note 1. For example, t_{DDKHMH} describes the DDR timing (DD) from the rising edge of the MCK(n) clock (KH) until the MDQS signal is valid (MH). t_{DDKHMH} can be modified through control of the DQSS override bits in the TIMING_CFG_2 register. This is typically set to the same delay as the clock adjusts in the CLK_CNTL register. The timing parameters listed in the table assume that these 2 parameters have been set to the same adjustment value. See the *MPC8309 PowerQUICC II Pro Integrated Communications Processor Family Reference Manual* for a description and understanding of the timing modifications enabled by use of these bits.
5. Determined by maximum possible skew between a data strobe (MDQS) and any corresponding bit of data (MDQ), or data mask (MDM). The data strobe should be centered inside of the data eye at the pins of the microprocessor.
6. t_{DDKHMP} follows the symbol conventions described in note 1.

7 Enhanced local bus

This section describes the DC and AC electrical specifications for the enhanced local bus interface of the MPC8309.

7.1 Enhanced local bus DC electrical characteristics

The following table provides the DC electrical characteristics for the enhanced local bus interface.

Table 17. Enhanced local bus DC electrical characteristics

Parameter	Symbol	Min	Max	Unit
High-level input voltage	V_{IH}	2	OV_{DD} + 0.3	V
Low-level input voltage	V_{IL}	–0.3	0.8	V
High-level output voltage, I_{OH} = –100 µA	V_{OH}	OV_{DD} – 0.2	—	V
Low-level output voltage, I_{OL} = 100 µA	V_{OL}	—	0.2	V
Input current	I_{IN}	—	±5	µA

7.2 Enhanced local bus AC electrical specifications

The following table describes the general timing parameters of the enhanced local bus interface of MPC8309.

Table 18. Enhanced local bus general timing parameters

Parameter	Symbol[1]	Min	Max	Unit	Note
Local bus cycle time	t_{LBK}	15	—	ns	2
Input setup to local bus clock (LCLK*n*)	t_{LBIVKH}	7	—	ns	3, 4
Input hold from local bus clock (LCLK*n*)	t_{LBIXKH}	1.0	—	ns	3, 4
Local bus clock (LCLK*n*) to output valid	t_{LBKHOV}	—	3	ns	3
Local bus clock (LCLK*n*) to output high impedance for LAD/LDP	t_{LBKHOZ}	—	4	ns	5
LALE output fall to LAD output transition (LATCH hold time)	t_{LBOTOT}	3	—	ns	—
LALE output rise to LCLK negative edge	$t_{LALEHOV}$	—	3	ns	—
LALE output fall to LCLK negative edge	$t_{LALETOT}$	–5.0	—	ns	—

Notes:

1. The symbols used for timing specifications follow the pattern of $t_{\text{(first two letters of functional block)(signal)(state)(reference)(state)}}$ for inputs and $t_{\text{(first two letters of functional block)(reference)(state)(signal)(state)}}$ for outputs. For example, $t_{LBIXKH1}$ symbolizes local bus timing (LB) for the input (I) to go invalid (X) with respect to the time the t_{LBK} clock reference (K) goes high (H), in this case for clock one(1).
2. All timings are in reference to falling edge of LCLK0 (for all outputs and for $\overline{\text{LGTA}}$ and LUPWAIT inputs) or rising edge of LCLK0 (for all other inputs).
3. All signals are measured from $OV_{DD}/2$ of the rising/falling edge of LCLK0 to $0.4 \times OV_{DD}$ of the signal in question for 3.3-V signaling levels.
4. Input timings are measured at the pin.
5. For purposes of active/float timing measurements, the Hi-Z or off state is defined to be when the total current delivered through the component pin is less than or equal to the leakage current specification.

Table 19. MII and RMII DC electrical characteristics

Parameter	Symbol	Conditions		Min	Max	Unit
Supply voltage 3.3 V	OV_{DD}	—		3	3.6	V
Output high voltage	V_{OH}	I_{OH} = –4.0 mA	OV_{DD} = Min	2.40	OV_{DD} + 0.3	V
Output low voltage	V_{OL}	I_{OL} = 4.0 mA	OV_{DD} = Min	GND 0.	50	V
Input high voltage	V_{IH}	—	—	2.0	OV_{DD} + 0.3	V
Input low voltage	V_{IL}	—	—	–0.3	0.90	V
Input current	I_{IN}	$0 V \le V_{IN} \le OV_{DD}$		—	±5	μA

8.2 MII and RMII AC timing specifications

The AC timing specifications for MII and RMII are presented in this section.

8.2.1 MII AC timing specifications

This section describes the MII transmit and receive AC timing specifications.

8.2.1.1 MII transmit AC timing specifications

The following table provides the MII transmit AC timing specifications.

Table 20. MII transmit AC timing specifications

At recommended operating conditions with OV_{DD} of 3.3 V ± 300mV.

Parameter/Condition	Symbol[1]	Min	Typical	Max	Unit
TX_CLK clock period 10 Mbps	t_{MTX}	—	400	—	ns
TX_CLK clock period 100 Mbps	t_{MTX}	—	40	—	ns
TX_CLK duty cycle	t_{MTXH}/t_{MTX}	35	—	65	%
TX_CLK to MII data TXD[3:0], TX_ER, TX_EN delay	t_{MTKHDX}	1	5	15	ns
TX_CLK data clock rise V_{IL}(min) to V_{IH}(max)	t_{MTXR}	1.0	—	4.0	ns
TX_CLK data clock fall V_{IH}(max) to V_{IL}(min) t	MTXF	1.0	—	4.0	ns

Note:

1. The symbols used for timing specifications follow the pattern of $t_{\text{(first two letters of functional block)(signal)(state)(reference)(state)}}$ for inputs and $t_{\text{(first two letters of functional block)(reference)(state)(signal)(state)}}$ for outputs. For example, t_{MTKHDX} symbolizes MII transmit timing (MT) for the time t_{MTX} clock reference (K) going high (H) until data outputs (D) are invalid (X). Note that, in general, the clock reference symbol representation is based on two to three letters representing the clock of a particular functional. For example, the subscript of t_{MTX} represents the MII(M) transmit (TX) clock. For rise and fall times, the latter convention is used with the appropriate letter: R (rise) or F (fall).

The following figure shows the MII receive AC timing diagram.

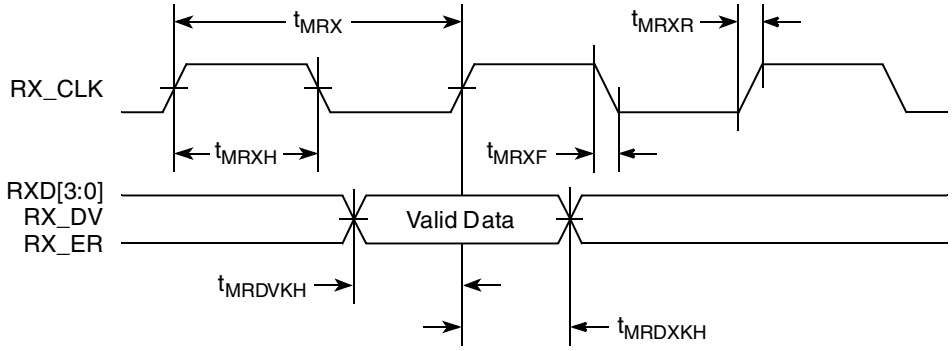


Figure 13. MII receive AC timing diagram

8.2.2 RMII AC timing specifications

This section describes the RMII transmit and receive AC timing specifications.

8.2.2.1 RMII transmit AC timing specifications

The following table provides the RMII transmit AC timing specifications.

Table 22. RMII transmit AC timing specifications

At recommended operating conditions with OV_{DD} of 3.3 V ± 300mV.

Parameter/Condition	Symbol[1]	Min	Typical	Max	Unit
REF_CLK clock	t_{RMX}	—	20	—	ns
REF_CLK duty cycle	t_{RMXH}/t_{RMX}	35	—	65	%
REF_CLK to RMII data TXD[1:0], TX_EN delay	$t_{RMTKHDX}$	2	—	13 ns	
REF_CLK data clock rise V_{IL}(min) to V_{IH}(max)	t_{RMXR}	1.0	—	4.0	ns
REF_CLK data clock fall V_{IH}(max) to V_{IL}(min) t	RMXF	1.0	—	4.0	ns

Note:

1. The symbols used for timing specifications follow the pattern of $t_{\text{(first three letters of functional block)(signal)(state)(reference)(state)}}$ for inputs and $t_{\text{(first two letters of functional block)(reference)(state)(signal)(state)}}$ for outputs. For example, $t_{RMTKHDX}$ symbolizes RMII transmit timing (RMT) for the time t_{RMX} clock reference (K) going high (H) until data outputs (D) are invalid (X). Note that, in general, the clock reference symbol representation is based on two to three letters representing the clock of a particular functional. For example, the subscript of t_{RMX} represents the RMII(RM) reference (X) clock. For rise and fall times, the latter convention is used with the appropriate letter: R (rise) or F (fall).

The following figure provides the AC test load.

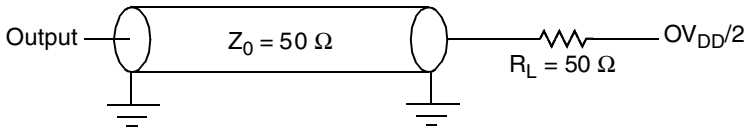


Figure 14. AC test load

Table 29. HDLC AC timing specifications[1] (continued)

Characteristic	Symbol[2]	Min	Max	Unit
Outputs—External clock high impedance	t_{HEKHOX}	1	8	ns
Inputs—Internal clock input setup time	t_{HIIVKH}	9	—	ns
Inputs—External clock input setup time	t_{HEIVKH}	4	—	ns
Inputs—Internal clock input hold time	t_{HIIXKH}	0	—	ns
Inputs—External clock input hold time	t_{HEIXKH}	1	—	ns

Notes:
1. Output specifications are measured from the 50% level of the rising edge of QE_CLK_IN to the 50% level of the signal. Timings are measured at the pin.
2. The symbols used for timing specifications follow the pattern of $t_{\text{(first two letters of functional block)(signal)(state)(reference)(state)}}$ for inputs and $t_{\text{(first two letters of functional block)(reference)(state)(signal)(state)}}$ for outputs. For example, t_{HIKHOX} symbolizes the outputs internal timing (HI) for the time t_{serial} memory clock reference (K) goes from the high state (H) until outputs (O) are invalid (X).

The following figure provides the AC test load.

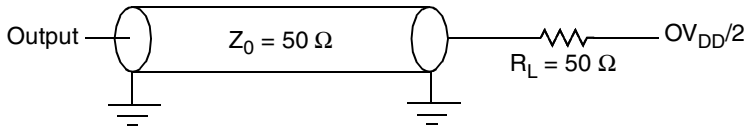
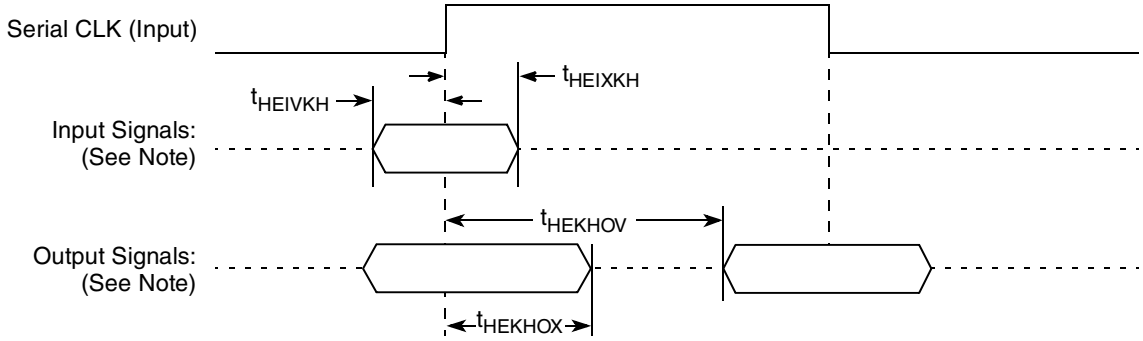


Figure 20. AC test load

Figure 21 and Figure 22 represent the AC timing from Table 29. Note that although the specifications generally reference the rising edge of the clock, these AC timing diagrams also apply when the falling edge is the active edge.

The following figure shows the timing with external clock.



Note: The clock edge is selectable.

Figure 21. AC timing (external clock) diagram

Figure 24 shows the PCI input AC timing conditions.

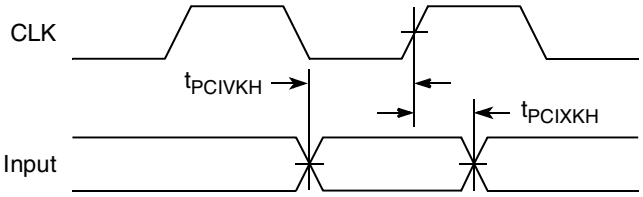


Figure 24. PCI input AC timing measurement conditions

Figure 25 shows the PCI output AC timing conditions.

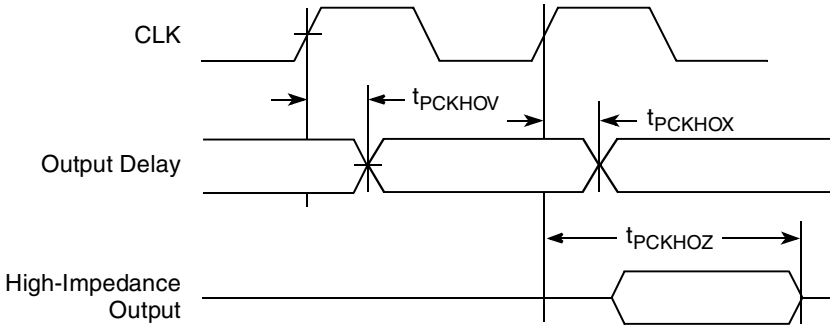


Figure 25. PCI output AC timing measurement condition

12 USB

12.1 USB controller

This section provides the AC and DC electrical specifications for the USB (ULPI) interface.

12.1.1 USB DC electrical characteristics

The following table provides the DC electrical characteristics for the USB interface.

Table 33. USB DC electrical characteristics

Parameter	Symbol	Min	Max	Unit
High-level input voltage	V_{IH}	2.0	OV_{DD} + 0.3	V
Low-level input voltage	V_{IL}	–0.3	0.8	V
Input current	I_{IN}	—	±5	μA
High-level output voltage, I_{OH} = –100 μA	V_{OH}	OV_{DD} – 0.2	—	V
Low-level output voltage, I_{OL} = 100 μA	V_{OL}	—	0.2	V

12.1.2 USB AC electrical specifications

The following table describes the general timing parameters of the USB interface.

Table 38. eSDHC AC timing specifications (continued)

At recommended operating conditions with OV_{DD} = 3.3 V

Parameter	Symbol[1]	Min	Max	Unit	Notes
Input hold times: SD_CMD, SD_DATx, SD_CD to SD_CLK	$t_{SHSIXKH}$	2.5	—	ns	3, 4
Output delay time: SD_CLK to SD_CMD, SD_DATx valid	$t_{SHSKHOV}$	–3	3	ns	4

Notes:

1. The symbols used for timing specifications herein follow the pattern of $t_{\text{(first three letters of functional block)(signal)(state)(reference)(state)}}$ for inputs and $t_{\text{(first three letters of functional block)(reference)(state)(signal)(state)}}$ for outputs. For example, $t_{FHSKHOV}$ symbolizes eSDHC high-speed mode device timing (SHS) clock reference (K) going to the high (H) state, with respect to the output (O) reaching the invalid state (X) or output hold time. Note that in general, the clock reference symbol is based on five letters representing the clock of a particular functional. For rise and fall times, the latter convention is used with the appropriate letter: R (rise) or F (fall).
2. In full-speed mode, the clock frequency value can be 0–25 MHz for an SD/SDIO card and 0–20 MHz for an MMC card. In high-speed mode, the clock frequency value can be 0–33.25 MHz for an SD/SDIO card and 0–52 MHz for an MMC card.
3. To satisfy hold timing, the delay difference between clock input and cmd/data input must not exceed 2 ns.
4. $C_{CARD} \leq 10$ pF, (1 card), and $C_L = C_{BUS} + C_{HOST} + C_{CARD} \leq 40$ pF

The following figure provides the eSDHC clock input timing diagram.

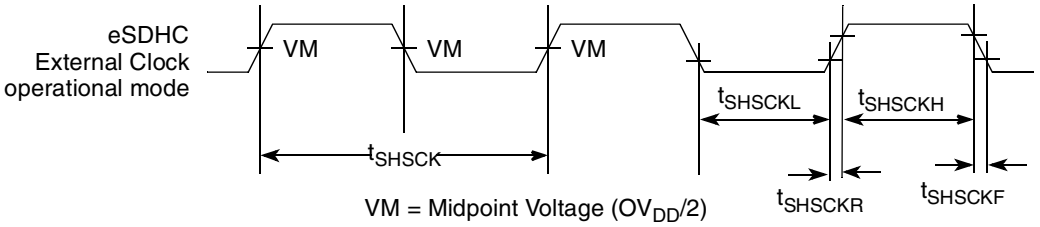


Figure 28. eSDHC clock input timing diagram

The following figure provides the data and command input/output timing diagram.

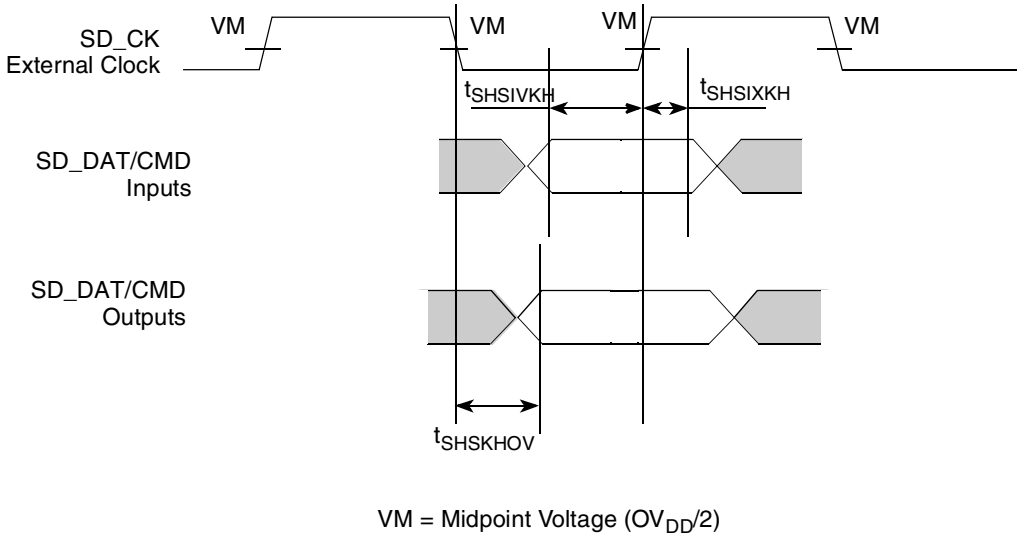


Figure 29. eSDHC data and command input/output timing diagram referenced to clock

17 Timers

This section describes the DC and AC electrical specifications for the timers of the MPC8309.

17.1 Timer DC electrical characteristics

The following table provides the DC electrical characteristics for the MPC8309 timer pins, including TIN, $\overline{\text{TOUT}}$, $\overline{\text{TGATE}}$, and RTC_PIT_CLK.

Table 43. Timer DC electrical characteristics

Characteristic	Symbol	Condition	Min	Max	Unit
Output high voltage	V_{OH}	I_{OH} = –6.0 mA 2.	4	—	V
Output low voltage	V_{OL}	I_{OL} = 6.0 mA	—	0.5	V
Output low voltage	V_{OL}	I_{OL} = 3.2 mA	—	0.4	V
Input high voltage	V_{IH}	—	2.0	OV_{DD} + 0.3	V
Input low voltage	V_{IL}	—	–0.3	0.8	V
Input current	I_{IN}	0 V ≤ V_{IN} ≤ OV_{DD}	— ±	5	μA

17.2 Timer AC timing specifications

The following table provides the timer input and output AC timing specifications.

Table 44. Timer input AC timing specifications[1]

Characteristic	Symbol[2]	Min	Unit
Timers inputs—minimum pulse width	t_{TIWID}	20	ns

Notes:

1. Input specifications are measured from the 50% level of the signal to the 50% level of the rising edge of SYS_CLK_IN. Timings are measured at the pin.
2. Timer inputs and outputs are asynchronous to any visible clock. Timer outputs should be synchronized before use by any external synchronous logic. Timer inputs are required to be valid for at least t_{TIWID} ns to ensure proper operation.

The following figure provides the AC test load for the timers.

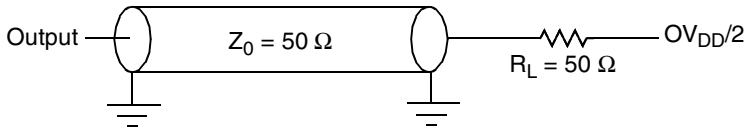
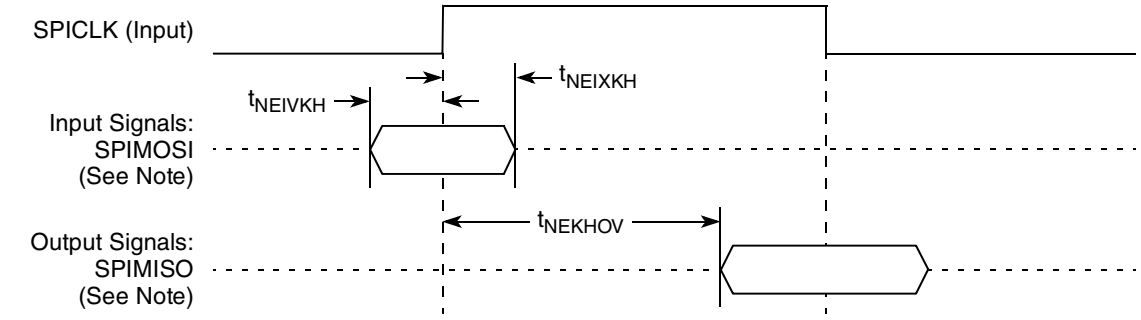


Figure 32. Timers AC test load

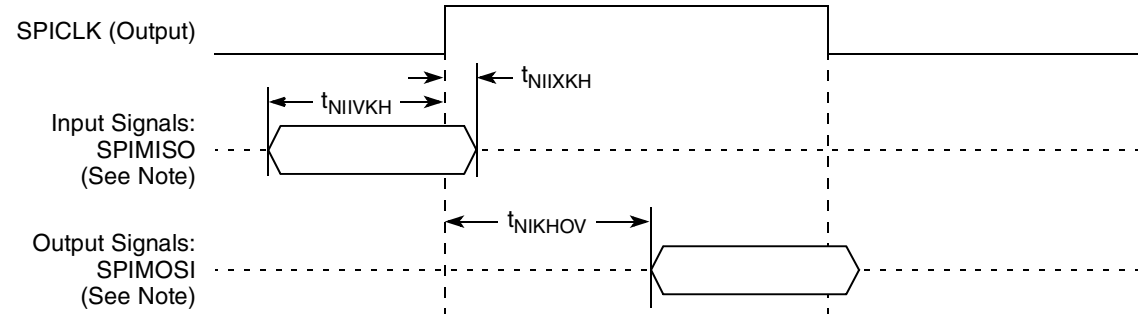
The following figure shows the SPI timing in slave mode (external clock).



Note: The clock edge is selectable on SPI.

Figure 35. SPI AC Timing in slave mode (external clock) diagram

The following figure shows the SPI timing in master mode (internal clock).



Note: The clock edge is selectable on SPI.

Figure 36. SPI AC timing in master mode (internal clock) diagram

21 JTAG

This section describes the DC and AC electrical specifications for the IEEE Std. 1149.1™ (JTAG) interface of the MPC8309.

21.1 JTAG DC electrical characteristics

The following table provides the DC electrical characteristics for the IEEE Std. 1149.1 (JTAG) interface of the MPC8309.

Table 51. JTAG interface DC electrical characteristics

Characteristic	Symbol	Condition	Min	Max	Unit
Output high voltage	V_{OH}	I_{OH} = –6.0 mA 2.	4	—	V
Output low voltage	V_{OL}	I_{OL} = 6.0 mA	—	0.5	V
Output low voltage	V_{OL}	I_{OL} = 3.2 mA	—	0.4	V

MEMC_MA13	P1	O	GV_{DD}	-
MEMC_MWE_B	J1	O	GV_{DD}	-
MEMC_MRAS_B	K1	O	GV_{DD}	-
MEMC_MCAS_B	J3	O	GV_{DD}	-
MEMC_MCS_B0	J4	O	GV_{DD}	-
MEMC_MCS_B1	K5	O	GV_{DD}	-
MEMC_MCKE	P4	O	GV_{DD}	-
MEMC_MCK0	R1	O	GV_{DD}	-
MEMC_MCK1	R3	O	GV_{DD}	-
MEMC_MCK_B0	T1	O	GV_{DD}	-
MEMC_MCK_B1	P3	O	GV_{DD}	-
MEMC_MODT0	H1	O	GV_{DD}	-
MEMC_MODT1	H2	O	GV_{DD}	-
MEMC_MVREF	M6		GV_{DD}	-
Local Bus Controller Interface				
LAD0	B5	IO	OV_{DD}	-
LAD1	A4	IO	OV_{DD}	-
LAD2	C7	IO	OV_{DD}	-
LAD3	D9	IO	OV_{DD}	-
LAD4	A5	IO	OV_{DD}	-
LAD5	E10	IO	OV_{DD}	-
LAD6	A6	IO	OV_{DD}	-
LAD7	C8	IO	OV_{DD}	-
LAD8	D10	IO	OV_{DD}	-
LAD9	A7	IO	OV_{DD}	-
LAD10	B7	IO	OV_{DD}	-
LAD11	C9	IO	OV_{DD}	-
LAD12	E11	IO	OV_{DD}	-
LAD13	B8	IO	OV_{DD}	-
LAD14	A8	IO	OV_{DD}	-
LAD15	C10	IO	OV_{DD}	-
LA16	C11	IO	OV_{DD}	-
LA17	B10	O	OV_{DD}	-
LA18	D12	O	OV_{DD}	-
LA19	A9	O	OV_{DD}	-
LA20	E12	O	OV_{DD}	-
LA21	B11	O	OV_{DD}	-

LA22	A11	O	OV_{DD}	-
LA23	A10	O	OV_{DD}	-
LA24	C12	O	OV_{DD}	-
LA25	A12	O	OV_{DD}	-
LCLK0	E13	O	OV_{DD}	-
LCS_B0	D13	O	OV_{DD}	2
LCS_B1	C13	O	OV_{DD}	2
LCS_B2	A13	O	OV_{DD}	2
LCS_B3	B13	O	OV_{DD}	2
LWE_B0/LFWE_B0/LBS_B0	A14	O	OV_{DD}	-
LWE_B1/LBS_B1	B14	O	OV_{DD}	-
LBCTL	A15	O	OV_{DD}	-
LGPL0/LFCLE	C14	O	OV_{DD}	-
LGPL1/LFALE	C15	O	OV_{DD}	-
LGPL2/LOE_B/LFRE_B	B16	O	OV_{DD}	2
LGPL3/LFWP_B	A16	O	OV_{DD}	-
LGPL4/LGTA_B/LUPWAIT/LFRB_B	E14	IO	OV_{DD}	2
LGPL5	B17	O	OV_{DD}	-
LALE	A17	O	OV_{DD}	-
DUART				
UART1_SOUT1	AB7	O	OV_{DD}	-
UART1_SIN1	AC6	I	OV_{DD}	-
UART1_SOUT2/UART1_RTS_B1	W10	O	OV_{DD}	-
UART1_SIN2/UART1_CTS_B1	Y9	I	OV_{DD}	-
I2C				
IIC_SDA1 A20		IO	OV_{DD}	1
IIC_SCL1	B20	IO	OV_{DD}	1
IIC_SDA2 /CKSTOP_OUT_B	D19	IO	OV_{DD}	1
IIC_SCL2/CKSTOP_IN_B	C20	IO	OV_{DD}	1
Interrupts				
IRQ_B0_MCP_IN_B	A21	IO	OV_{DD}	-
IRQ_B1/MCP_OUT_B	A22	IO	OV_{DD}	-
IRQ_B2/CKSTOP_IN_B	E18	I	OV_{DD}	-
IRQ_B3/CKSTOP_OUT_B/INTA_B	E19	IO	OV_{DD}	-
SPI				
SPIMOSI	B19	IO	OV_{DD}	-

PCI_REQ_B0 P21		IO	OV_{DD}	-
PCI_REQ_B1/CPCI_HS_ES	P22	IO	OV_{DD}	-
PCI_REQ_B2	T22	IO	OV_{DD}	-
PCI_GNT_B0	T21	IO	OV_{DD}	-
PCI_GNT_B1/CPCI_HS_LED	U22	O	OV_{DD}	-
PCI_GNT_B2/CPCI_HS_ENUM	U21	IO	OV_{DD}	-
M66EN	V21	I	OV_{DD}	-
PCI_CLK0	T19	O	OV_{DD}	-
PCI_CLK1	U19	O	OV_{DD}	-
PCI_CLK2	R19	O	OV_{DD}	-
Ethernet Management				
FEC_MDC	W18	O	OV_{DD}	-
FEC_MDIO	W17	IO	OV_{DD}	-
FEC/GTM/GPIO				
FEC1_COL/GTM1_TIN1/GPIO_16	Y18	IO	OV_{DD}	-
FEC1_CRS/GTM1_TGATE1_B/GPIO_17	AA19	IO	OV_{DD}	-
FEC1_RX_CLK[CLK9]/GPIO_18	W16	IO	OV_{DD}	-
FEC1_RX_DV/GTM1_TIN2/GPIO_19	AC22	IO	OV_{DD}	-
FEC1_RX_ER/GTM1_TGATE2_B/GPIO_20	AA18	IO	OV_{DD}	-
FEC1_RXD0/GPIO_21	AB20	IO	OV_{DD}	-
FEC1_RXD1/GTM1_TIN3/GPIO_22	Y17	IO	OV_{DD}	-
FEC1_RXD2/GTM1_TGATE3_B/GPIO_23	AB19	IO	OV_{DD}	-
FEC1_RXD3/GPIO_24	AC21	IO	OV_{DD}	-
FEC1_TX_CLK[CLK10]/GTM1_TIN4/GPIO_25	W15	IO	OV_{DD}	-
FEC1_TX_EN/GTM1_TGATE4_B/GPIO_26	AC19	IO	OV_{DD}	-
FEC1_TX_ER/GTM1_TOUT4_B/GPIO_27	AC20	IO	OV_{DD}	-
FEC1_TXD0/GTM1_TOUT1_B/GPIO_28/	AA17	IO	OV_{DD}	-
FEC1_TXD1/GTM1_TOUT2_B/GPIO_29	AC18	IO	OV_{DD}	-
FEC1_TXD2/GTM1_TOUT3_B/GPIO_30	AA16	IO	OV_{DD}	-
FEC1_TXD3/GPIO_31	AB17	IO	OV_{DD}	-
FEC2_COL/GTM2_TIN1/GPIO_32	Y15	IO	OV_{DD}	-
FEC2_CRS/GTM2_TGATE1_B/GPIO_33	AC17	IO	OV_{DD}	-

FEC2_RX_CLK[CLK7]/GPIO_34	W14	IO	OV_{DD}	-
FEC2_RX_DV/GTM2_TIN2/GPIO_35	AB16	IO	OV_{DD}	-
FEC2_RX_ER/GTM2_TGATE2_B/GPIO_36	Y14	IO	OV_{DD}	-
FEC2_RXD0/GPIO_37	AA15	IO	OV_{DD}	-
FEC2_RXD1/GTM2_TIN3/GPIO_38	AC15	IO	OV_{DD}	-
FEC2_RXD2/GTM2_TGATE3_B/GPIO_39	AC16	IO	OV_{DD}	-
FEC2_RXD3/GPIO_40	AA14	IO	OV_{DD}	-
FEC2_TX_CLK[CLK8]/GTM2_TIN4/GPIO_41	W13	IO	OV_{DD}	-
FEC2_TX_EN/GTM2_TGATE4_B/GPIO_42	AB14	IO	OV_{DD}	-
FEC2_TX_ER/GTM2_TOUT4_B/GPIO_43	AC14	IO	OV_{DD}	-
FEC2_TXD0/GTM2_TOUT1_B/GPIO_44	Y12	IO	OV_{DD}	-
FEC2_TXD1/GTM2_TOUT2_B/GPIO_45	AA13	IO	OV_{DD}	-
FEC2_TXD2/GTM2_TOUT3_B/GPIO_46	AB13	IO	OV_{DD}	-
FEC2_TXD3/GPIO_47	AC13	IO	OV_{DD}	-
FEC3_COL/GPIO_48	AC12	IO	OV_{DD}	-
FEC3_CRS/GPIO_49	W11	IO	OV_{DD}	-
FEC3_RX_CLK[CLK11]/GPIO_50	W12	IO	OV_{DD}	-
FEC3_RX_DV/FEC1_TMR_TX_ESFD/GPIO_51	AA12	IO	OV_{DD}	-
FEC3_RX_ER/FEC1_TMR_RX_ESFD/GPIO_52	AB11	IO	OV_{DD}	-
FEC3_RXD0/FEC2_TMR_TX_ESFD/GPIO_53	AA11	IO	OV_{DD}	-
FEC3_RXD1/FEC2_TMR_RX_ESFD/GPIO_54	AC11	IO	OV_{DD}	-
FEC3_RXD2/FEC_TMR_TRIG1/GPIO_55	Y11	IO	OV_{DD}	-
FEC3_RXD3/FEC_TMR_TRIG2/GPIO_56	AB10	IO	OV_{DD}	-
FEC3_TX_CLK[CLK12]/FEC_TMR_CLK/GPIO_57	AC10	IO	OV_{DD}	-
FEC3_TX_EN/FEC_TMR_GCLK/GPIO_58	AA10	IO	OV_{DD}	-
FEC3_TX_ER/FEC_TMR_PP1/GPIO_59	AC8	IO	OV_{DD}	-
FEC3_TXD0/FEC_TMR_PP2/GPIO_60	AB8	IO	OV_{DD}	-
FEC3_TXD1/FEC_TMR_PP3/GPIO_61	AA9	IO	OV_{DD}	-
FEC3_TXD2/FEC_TMR_ALARM1/GPIO_62	AA8	IO	OV_{DD}	-
FEC3_TXD3/FEC_TMR_ALARM2/GPIO_63	AC7	IO	OV_{DD}	-

Table 55. Operating Frequencies for MAPBGA (continued)

Characteristic[1]	Max Operating Frequency	Unit
DDR2 memory bus frequency (MCLK)[2]	167	MHz
Local bus frequency (LCLK*n*)[3]	66	MHz

Notes:
1. The SYS_CLK_IN frequency, RCWL[SPMF], and RCWL[COREPLL] settings must be chosen such that the resulting csb_clk, MCLK, LCLK, and core_clk frequencies do not exceed their respective maximum or minimum operating frequencies.
2. The DDR2 data rate is 2× the DDR2 memory bus frequency.
3. The local bus frequency is 1/2, 1/4, or 1/8 of the lb_clk frequency (depending on LCRR[CLKDIV]) which is in turn 1× or 2× the csb_clk frequency (depending on RCWL[LBCM]).

23.4 System PLL configuration

The system PLL is controlled by the RCWL[SPMF] parameter. Table 56 shows the multiplication factor encodings for the system PLL.

NOTE

System PLL VCO frequency = 2 × (CSB frequency) × (System PLL VCO divider). The VCO divider needs to be set properly so that the System PLL VCO frequency is in the range of 450–750 MHz.

Table 56. System PLL multiplication factors

RCWL[SPMF]	System PLL Multiplication Factor
0000	Reserved
0001	Reserved
0010	× 2
0011	× 3
0100	× 4
0101	× 5
0110	× 6
0111–1111	Reserved

As described in Section 23, “Clocking,” the LBCM, DDRCM, and SPMF parameters in the reset configuration word low select the ratio between the primary clock input (*SYS_CLK_IN)* and the internal coherent system bus clock (*csb_clk*). The following table shows the expected frequency values for the CSB frequency for selected *csb_clk* to *SYS_CLK_IN* ratios.

T_A = ambient temperature for the package (°C)

$R_{\theta JA}$ = junction-to-ambient thermal resistance (°C/W)

P_D = power dissipation in the package (W)

The junction-to-ambient thermal resistance is an industry standard value that provides a quick and easy estimation of thermal performance. As a general statement, the value obtained on a single layer board is appropriate for a tightly packed printed-circuit board. The value obtained on the board with the internal planes is usually appropriate if the board has low power dissipation and the components are well separated. Test cases have demonstrated that errors of a factor of two (in the quantity $T_J - T_A$) are possible.

24.1.3 Estimation of junction temperature with junction-to-board thermal resistance

The thermal performance of a device cannot be adequately predicted from the junction-to-ambient thermal resistance. The thermal performance of any component is strongly dependent on the power dissipation of surrounding components. In addition, the ambient temperature varies widely within the application. For many natural convection and especially closed box applications, the board temperature at the perimeter (edge) of the package is approximately the same as the local air temperature near the device. Specifying the local ambient conditions explicitly as the board temperature provides a more precise description of the local ambient conditions that determine the temperature of the device.

At a known board temperature, the junction temperature is estimated using the following equation:

$$T_J = T_B + (R_{\theta JB} \times P_D) \quad \text{Eqn. 2}$$

where,

T_J = junction temperature (°C)

T_B = board temperature at the package perimeter (°C)

$R_{\theta JB}$ = junction-to-board thermal resistance (°C/W) per JESD51-8

P_D = power dissipation in package (W)

When the heat loss from the package case to the air can be ignored, acceptable predictions of junction temperature can be made. The application board should be similar to the thermal test condition: the component is soldered to a board with internal planes.

24.1.4 Experimental determination of junction temperature

To determine the junction temperature of the device in the application after prototypes are available, the thermal characterization parameter (Ψ_{JT}) can be used to determine the junction temperature with a measurement of the temperature at the top center of the package case using the following equation:

$$T_J = T_T + (\Psi_{JT} \times P_D) \quad \text{Eqn. 3}$$

where,

T_J = junction temperature (°C)

T_T = thermocouple temperature on top of package (°C)

Ψ_{JT} = thermal characterization parameter (°C/W)

P_D = power dissipation in package (W)

The thermal characterization parameter is measured per JESD51-2 specification using a 40 gauge type T thermocouple epoxied to the top center of the package case. The thermocouple should be positioned so that the thermocouple junction rests on the package. A small amount of epoxy is placed over the thermocouple junction and over about 1 mm of wire extending from the junction. The thermocouple wire is placed flat against the package case to avoid measurement errors caused by cooling effects of the thermocouple wire.

24.1.5 Heat sinks and junction-to-case thermal resistance

In some application environments, a heat sink is required to provide the necessary thermal management of the device. When a heat sink is used, the thermal resistance is expressed as the sum of a junction-to-case thermal resistance and a case to ambient thermal resistance as shown in the following equation:

$$R_{\theta JA} = R_{\theta JC} + R_{\theta CA} \qquad \textit{Eqn. 4}$$

where:

$R_{\theta JA}$ = junction-to-ambient thermal resistance (°C/W)

$R_{\theta JC}$ = junction-to-case thermal resistance (°C/W)

$R_{\theta CA}$ = case-to-ambient thermal resistance (°C/W)

$R_{\theta JC}$ is device related and cannot be influenced by the user. The user controls the thermal environment to change the case-to-ambient thermal resistance, $R_{\theta CA}$. For instance, the user can change the size of the heat sink, the air flow around the device, the interface material, the mounting arrangement on printed-circuit board, or change the thermal dissipation on the printed-circuit board surrounding the device.

To illustrate the thermal performance of the devices with heat sinks, the thermal performance has been simulated with a few commercially available heat sinks. The heat sink choice is determined by the application environment (temperature, air flow, adjacent component power dissipation) and the physical space available. Because there is not a standard application environment, a standard heat sink is not required.

Accurate thermal design requires thermal modeling of the application environment using computational fluid dynamics software which can model both the conduction cooling and the convection cooling of the air moving through the application. Simplified thermal models of the packages can be assembled using the junction-to-case and junction-to-board thermal resistances listed in the thermal resistance table. More detailed thermal models can be made available on request.

24.2 Heat sink attachment

When attaching heat sinks to these devices, an interface material is required. The best method is to use thermal grease and a spring clip. The spring clip should connect to the printed-circuit board, either to the board itself, to hooks soldered to the board, or to a plastic stiffener. Avoid attachment forces which would lift the edge of the package or peel the package from the board. Such peeling forces reduce the solder joint

25.2 PLL power supply filtering

Each of the PLLs listed above is provided with power through independent power supply pins. The voltage level at each $AV_{DD}n$ pin should always be equivalent to V_{DD}, and preferably these voltages are derived directly from V_{DD} through a low frequency filter scheme such as the following.

There are a number of ways to reliably provide power to the PLLs, but the recommended solution is to provide independent filter circuits as illustrated in Figure 44, one to each of the three AV_{DD} pins. By providing independent filters to each PLL the opportunity to cause noise injection from one PLL to the other is reduced.

This circuit is intended to filter noise in the PLLs resonant frequency range from a 500 kHz to 10 MHz range. It should be built with surface mount capacitors with minimum effective series inductance (ESL). Consistent with the recommendations of Dr. Howard Johnson in *High Speed Digital Design: A Handbook of Black Magic* (Prentice Hall, 1993), multiple small capacitors of equal value are recommended over a single large value capacitor.

Each circuit should be placed as close as possible to the specific AV_{DD} pin being supplied to minimize noise coupled from nearby circuits. It should be possible to route directly from the capacitors to the AV_{DD} pin, which is on the periphery of package, without the inductance of vias.

The following figure shows the PLL power supply filter circuit.

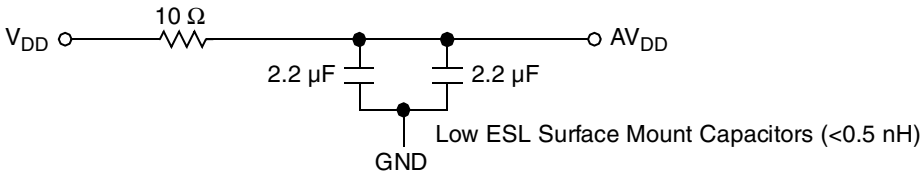


Figure 44. PLL power supply filter circuit

25.3 Decoupling recommendations

Due to large address and data buses, and high operating frequencies, the MPC8309 can generate transient power surges and high frequency noise in its power supply, especially while driving large capacitive loads. This noise must be prevented from reaching other components in the MPC8309 system, and MPC8309 itself requires a clean, tightly regulated source of power. Therefore, it is recommended that the system designer place at least one decoupling capacitor at each V_{DD}, OV_{DD}, and GV_{DD} pins of the MPC8309. These decoupling capacitors should receive their power from separate V_{DD}, OV_{DD}, GV_{DD}, and GND power planes in the PCB, utilizing short traces to minimize inductance. Capacitors may be placed directly under the device using a standard escape pattern. Others may surround the part.

These capacitors should have a value of 0.01 or 0.1 µF. Only ceramic SMT (surface mount technology) capacitors should be used to minimize lead inductance, preferably 0402 or 0603 sizes.

In addition, it is recommended that there be several bulk storage capacitors distributed around the PCB, feeding the V_{DD}, OV_{DD}, and GV_{DD} planes, to enable quick recharging of the smaller chip capacitors. These bulk capacitors should have a low ESR (equivalent series resistance) rating to ensure the quick response time necessary. They should also be connected to the power and ground planes through two vias

to minimize inductance. Suggested bulk capacitors—100 to 330 µF (AVX TPS tantalum or Sanyo OSCON).

25.4 Output buffer DC impedance

For all buses, the driver is a push-pull single-ended driver type (open drain for I^2C).

To measure Z_0 for the single-ended drivers, an external resistor is connected from the chip pad to OV_{DD} or GND. Then, the value of each resistor is varied until the pad voltage is $OV_{DD}/2$ (see Figure 45). The output impedance is the average of two components, the resistances of the pull-up and pull-down devices. When data is held high, SW1 is closed (SW2 is open) and R_P is trimmed until the voltage at the pad equals $OV_{DD}/2$. R_P then becomes the resistance of the pull-up devices. R_P and R_N are designed to be close to each other in value. Then, $Z_0 = (R_P + R_N)/2$.

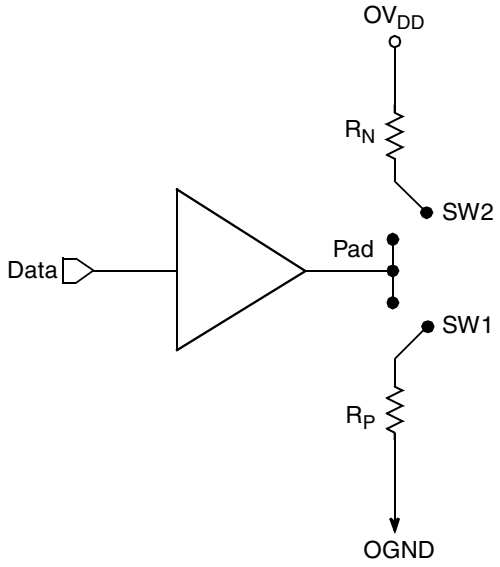


Figure 45. Driver impedance measurement

The value of this resistance and the strength of the driver's current source can be found by making two measurements. First, the output voltage is measured while driving logic 1 without an external differential termination resistor. The measured voltage is $V_1 = R_{source} \times I_{source}$. Second, the output voltage is measured while driving logic 1 with an external precision differential termination resistor of value R_{term}. The measured voltage is $V_2 = (1/(1/R_1 + 1/R_2)) \times I_{source}$. Solving for the output impedance gives $R_{source} = R_{term} \times (V_1/V_2 - 1)$. The drive current is then $I_{source} = V_1/R_{source}$.