Advance Information

MPC107EC/D
Rev. 4, 7/2003

MPC107
PCI Bridge/Memory Controller
Hardware Specifications

This document provides an overview of the MPC107 PCI bridge/memory controller (PCIB/MC) for high-performance embedded systems. The MPC107 is a cost-effective, general-purpose PCIB/MC for applications using PCI in networking infrastructure, telecommunications, and other embedded markets. It can be used in applications such as network routers and switches, mass storage subsystems, network appliances, and print and imaging systems.

This document describes pertinent electrical and physical characteristics of the MPC107. For functional characteristics of the processor, refer to the *MPC107 PCI Bridge/Memory Controller User's Manual* (MPC107UM/D).

This document contains the following topics:

To locate any published errata or updates for this document, refer to the web site at http://www.motorola.com/semiconductors.

1.1 Overview

The MPC107 integrates a PCI bridge, memory controller, DMA controller, PIC timers, a message unit with an Intelligent Input/Output (I_2O) message controller, and an Inter-Integrated Circuit (I^2C) controller. The integration reduces the overall packaging requirements and the number of discrete devices required for an embedded system.

Figure 1 shows the major functional units within the MPC107. Note that this is a conceptual block diagram intended to show basic features rather than an attempt to show how these features are physically implemented.

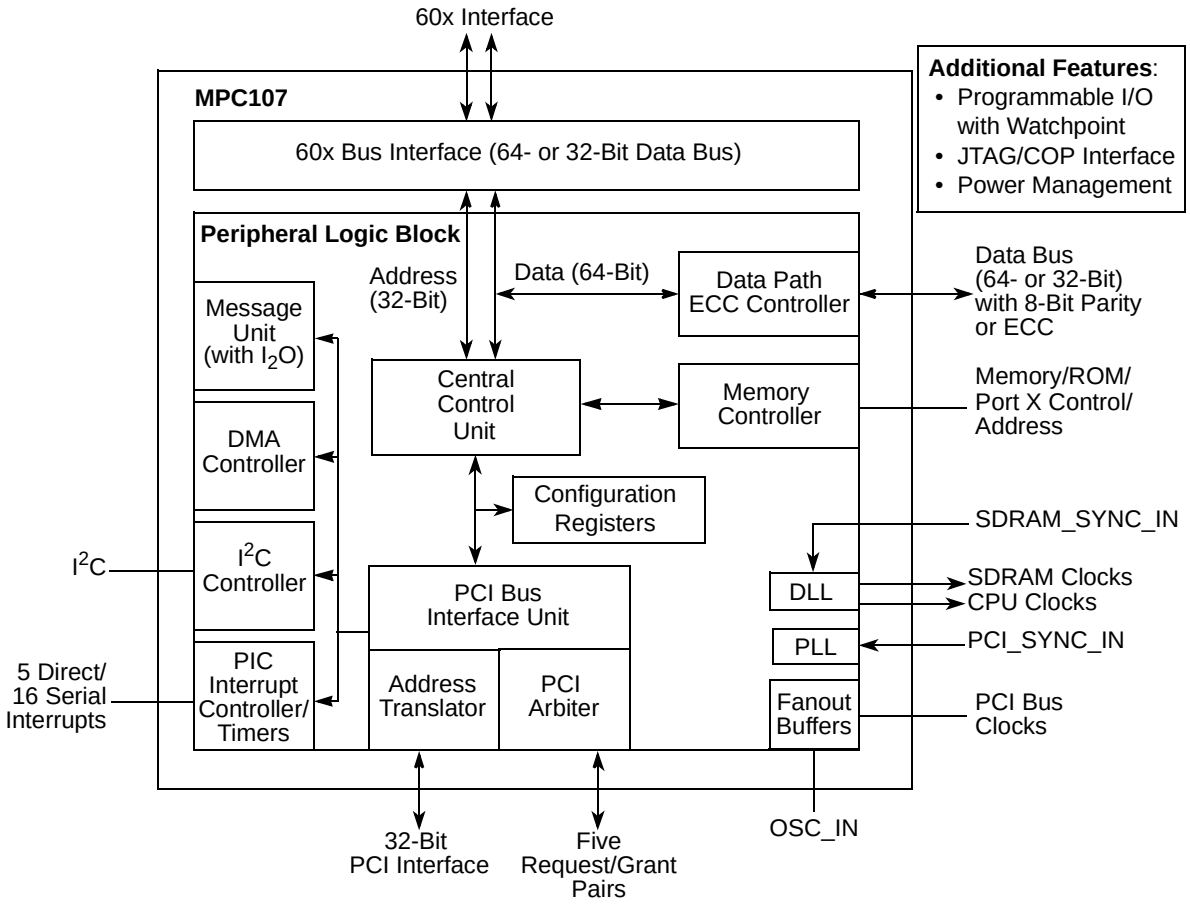


Figure 1. MPC107 Block Diagram

1.2 Features

The MPC107 provides an integrated high-bandwidth, high-performance interface for up to two 60x processors, the PCI bus, and main memory. This section summarizes the major features of the MPC107, as follows:

- Memory interface
  - — 64-/32-bit 100-MHz bus
  - — Programmable timing supporting either FPM DRAM, EDO DRAM, or SDRAM
  - — High-bandwidth bus (32-/64-bit data bus) to DRAM
  - — Supports one to eight banks of 4-, 16-, 64-, or 128-Mbit memory devices, and up to four banks of 256-Mbit SDRAM devices
  - — Supports 1-Mbyte to 1-Gbyte DRAM memory
  - — 144 Mbytes of ROM space
  - — 8-, 32-, or 64-bit ROM
  - — Write buffering for PCI and processor accesses
  - — Supports normal parity, read-modify-write (RMW), or ECC
  - — Data-path buffering between memory interface and processor

  - Low-voltage TTL logic (LVTTL) interfaces
  - Port X: 8-, 32-, or 64-bit general-purpose I/O port using ROM controller interface with programmable address strobe timing
- 32-bit PCI interface operating up to 66 MHz
  - PCI 2.1-compliant
  - PCI 5.0-V tolerance
  - Support for PCI locked accesses to memory
  - Support for accesses to PCI memory, I/O, and configuration spaces
  - Selectable big- or little-endian operation
  - Store gathering of processor-to-PCI write and PCI-to-memory write accesses
  - Memory prefetching of PCI read accesses
  - Selectable hardware-enforced coherency
  - PCI bus arbitration unit (five request/grant pairs)
  - PCI agent mode capability
  - Address translation unit
  - Some internal configuration registers accessible from PCI
- Two-channel integrated DMA controller (writes to ROM/Port X not supported)
  - Supports direct mode or chaining mode (automatic linking of DMA transfers)
  - Supports scatter gathering—read or write discontinuous memory
  - Interrupt on completed segment, chain, and error
  - Local-to-local memory
  - PCI-to-PCI memory
  - PCI-to-local memory
  - PCI memory-to-local memory
- Message unit
  - Two doorbell registers
  - An extended doorbell register mechanism that facilitates interprocessor communication through interrupts in a dual-local-processor system
  - Two inbound and two outbound messaging registers
  - I_2O message controller
- I^2C controller with full master/slave support (except broadcast all)
- Programmable interrupt controller (PIC)
  - Five hardware interrupts (IRQs) or 16 serial interrupts
  - Four programmable timers
- Integrated PCI bus, CPU, and SDRAM clock generation
- Programmable PCI bus, 60x, and memory interface output drivers
- Dynamic power management supporting 60x nap, doze, and sleep modes
- Programmable input and output signals with watchpoint capability

- Built-in PCI bus performance monitor facility
- Debug features
  - Error injection/capture on data path
  - IEEE 1149.1 (JTAG)/test interface
- Processor interface
  - Supports up to two PowerPC microprocessors with 60x bus interface
  - Supports various operating frequencies and bus divider ratios
  - 32-bit address bus, 64-/32-bit data bus supported at 100 MHz
  - Supports full memory coherency
  - Supports optional local bus slave
  - Decoupled address and data buses for pipelining of 60x accesses
  - Store gathering on 60x-to-PCI writes
  - Concurrent transactions on 60x and PCI buses supported

1.3 General Parameters

The following list provides a summary of the general parameters of the MPC107:

Technology	0.29 µm CMOS, five-layer metal
Die size	50 mm^2
Transistor count	0.96 million
Logic design	Fully-static
Package	Surface mount 503 flip chip plastic ball grid array (FC-PBGA)
Core power supply	2.5 V ± 5% V DC (nominal; see Table 2 for recommended operating conditions)
I/O power supply	3.0 to 3.6 V DC

1.4 Electrical and Thermal Characteristics

This section provides the AC and DC electrical specifications and thermal characteristics for the MPC107.

1.4.1 DC Electrical Characteristics

The following sections describe the absolute maximum ratings, recommended operating conditions, DC electrical specifics, characteristics of the output drivers, power consumption estimates, and thermal characteristics for the MPC107.

1.4.1.1 Absolute Maximum Ratings

The tables in this section describe the MPC107 DC electrical characteristics. Table 1 provides the absolute maximum ratings.

Table 1. Absolute Maximum Ratings

Characteristic [1]	Symbol	Range	Unit	Notes
Supply voltage—core	V_{DD}	–0.3 to 2.75	V	
Supply voltage—memory bus drivers	GV_{DD}	–0.3 to 3.6	V	
Supply voltage—processor bus drivers	BV_{DD}	–0.3 to 3.6	V	
Supply voltage—PCI and standard I/O buffers	OV_{DD}	–0.3 to 3.6	V	
Supply voltage—PLLs and DLL	AV_{DD}/LAV_{DD}	–0.3 to 2.75	V	
Supply voltage—PCI reference	LV_{DD}	–0.3 to 5.4	V	
Input voltage	V_{in}	–0.3 to 3.6	V	2
Operational die-junction temperature range	T_j	0 to 105	°C	
Storage temperature range	T_{stg}	–55 to 150	°C	

Notes:
1. Functional and tested operating conditions are given in Table 2. Absolute maximum ratings are stress ratings only, and functional operation at the maximums is not guaranteed. Stresses beyond those listed may affect device reliability or cause permanent damage to the device.
2. PCI inputs with LV_{DD} = 5 V ± 5% V DC may be correspondingly stressed at voltages exceeding LV_{DD} + 0.5 V DC.

1.4.1.2 Recommended Operating Conditions

Table 2 provides the recommended and tested operating conditions for the MPC107. Proper device operation outside of these conditions is not guaranteed.

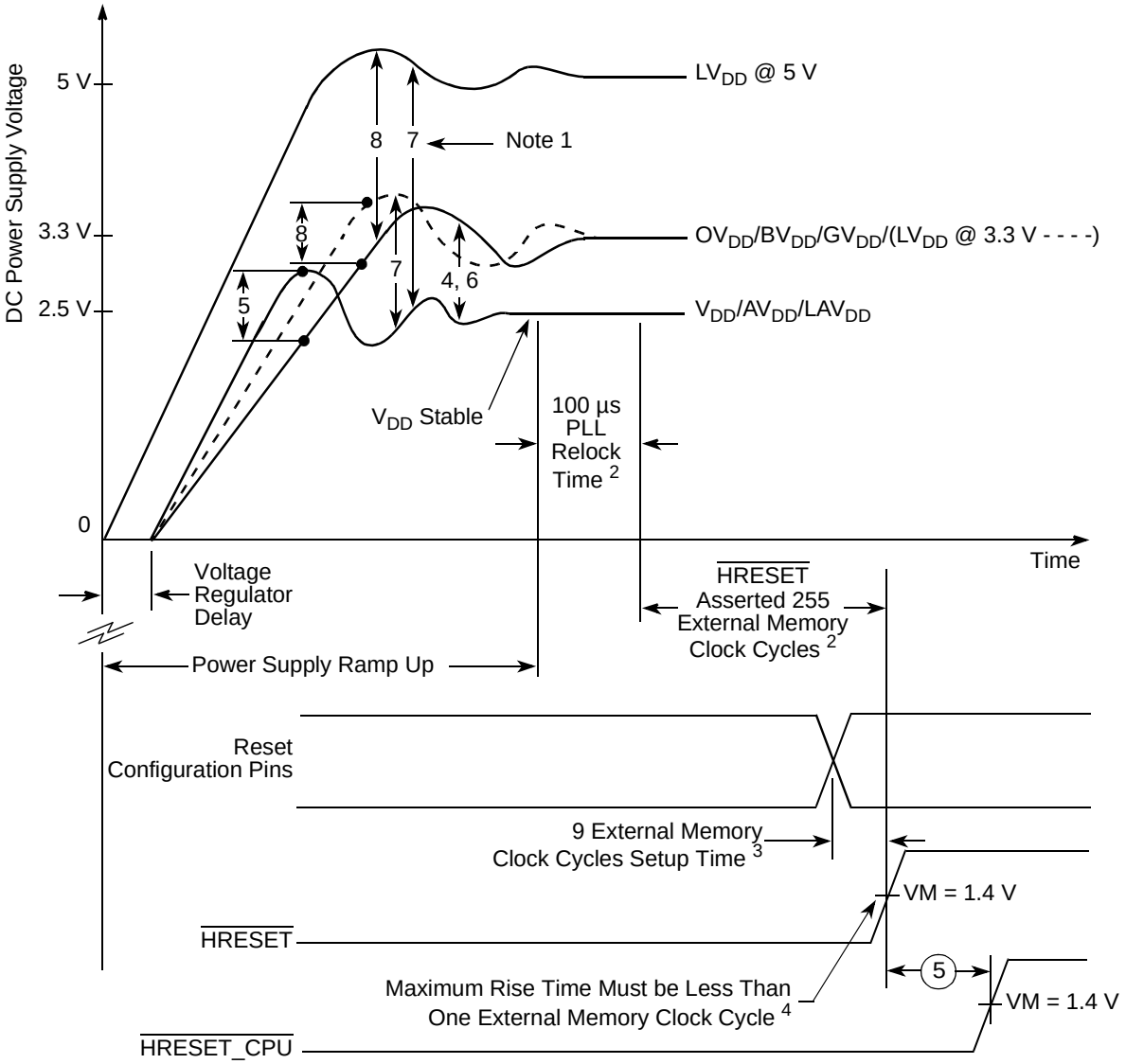
Table 2. Recommended Operating Conditions

Characteristic		Symbol	Recommended Value	Unit	Notes
Supply voltage		V_{DD}	2.5 ± 5%	V	4
Supply voltages for memory bus drivers		GV_{DD}	3.3 ± 5%	V	6
Supply voltages for processor bus drivers		BV_{DD}	3.3 ± 5%	V	6
			2.5 ± 5%		
I/O buffer supply for PCI and standard		OV_{DD}	3.3 ± 0.3	V	4
PLL supply voltage		AV_{DD}	2.5 ± 5%	V	5
DLL supply voltage		LAV_{DD}	2.5 ± 5%	V	5
PCI reference		LV_{DD}	5.0 ± 5%	V	7, 8
			3.3 ± 0.3	V	7, 8
Input voltage	PCI inputs	V_{in}	0 to 3.6 or 5.75	V	1, 2
	All other inputs		0 to 3.6	V	3
Die-junction temperature		T_j	0 to 105	°C	

Notes:
1. PCI pins are designed to withstand LV_{DD} + 0.5 V DC when LV_{DD} is connected to a 5.0-V DC power supply.
2. PCI pins are designed to withstand LV_{DD} + 0.5 V DC when LV_{DD} is connected to a 3.3-V DC power supply.

Cautions:
3. Input voltage (V_{in}) must not be greater than the supply voltage (V_{DD}/AV_{DD}/LAV_{DD}) by more than 2.5 V at all times, including during power-on reset.
4. OV_{DD} must not exceed V_{DD}/AV_{DD}/LAV_{DD} by more than 1.8 V at any time, including during power-on reset. This limit may be exceeded for a maximum of 20 ms during power-on reset and power-down sequences.
5. V_{DD}/AV_{DD}/LAV_{DD} must not exceed OV_{DD} by more than 0.6 V at any time, including during power-on reset. This limit may be exceeded for a maximum of 20 ms during power-on reset and power-down sequences.
6. BV_{DD}/GV_{DD} must not exceed V_{DD}/AV_{DD}/LAV_{DD} by more than 1.8 V at any time, including during power-on reset. This limit may be exceeded for a maximum of 20 ms during power-on reset and power-down sequences.
7. LV_{DD} must not exceed V_{DD}/AV_{DD}/LAV_{DD} by more than 5.4 V at any time, including during power-on reset. This limit may be exceeded for a maximum of 20 ms during power-on reset and power-down sequences.
8. LV_{DD} must not exceed OV_{DD} by more than 3.6 V at any time, including during power-on reset. This limit may be exceeded for a maximum of 20 ms during power-on reset and power-down sequences.

Figure 2 shows supply voltage sequencing and separation cautions.



Notes:
1. Numbers associated with waveform separations correspond to caution numbers listed in Table 2.
2. Refer to Table 8 for additional information on PLL relock and reset signal assertion timing requirements.
3. Refer to Table 9 for additional information on reset configuration pin setup timing requirements.
4. HRESET must transition from a logic 0 to a logic 1 in less than one SDRAM_SYNC_IN clock cycle for the device to be in the non-reset state.
5. HRESET_CPU negates 2^{17} memory clock cycles after HRESET negates.

Figure 2. Supply Voltage Sequencing and Separation Cautions

Figure 3 shows the undershoot and overshoot voltage for the MPC107 memory interface.

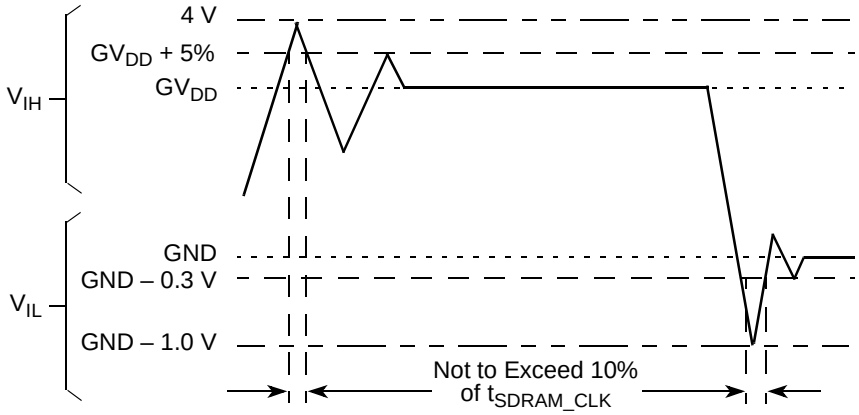


Figure 3. Overshoot/Undershoot Voltage

Figure 4 and Figure 5 show the undershoot/overshoot voltage of the PCI interface for 3.3- and 5-V signals, respectively.

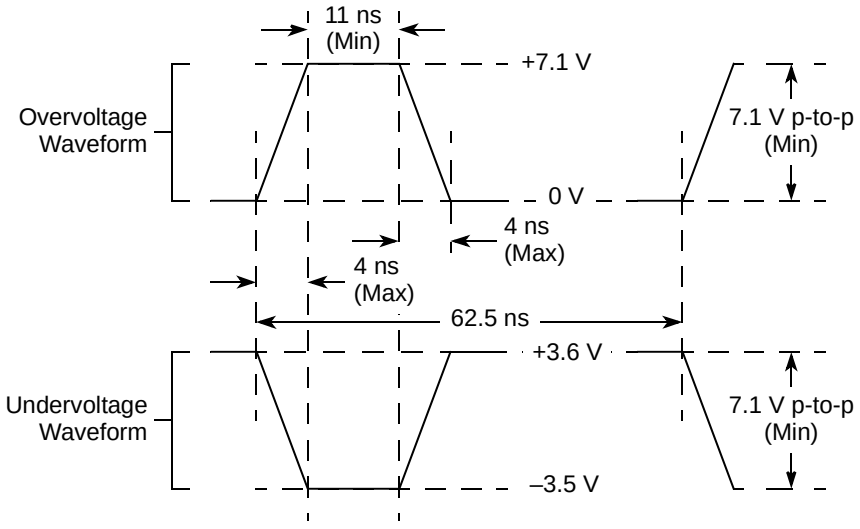


Figure 4. Maximum AC Waveforms for 3.3-V Signaling

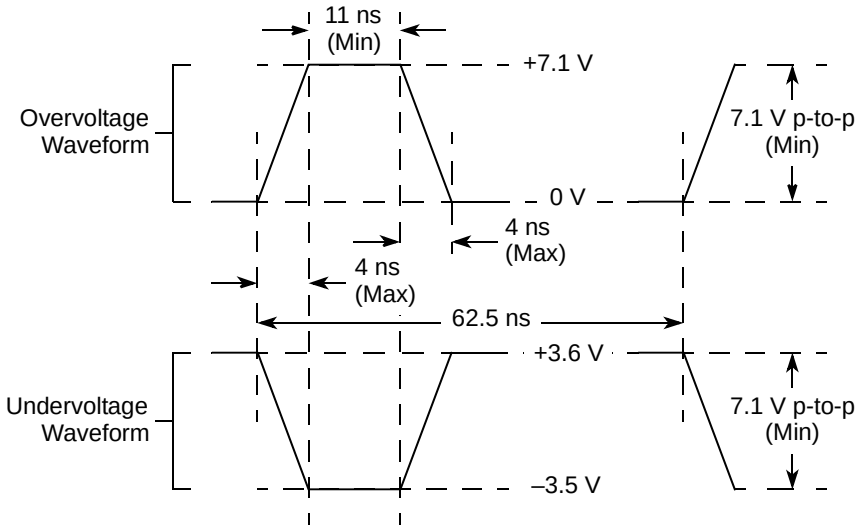


Figure 5. Maximum AC Waveforms for 5-V Signaling

1.4.1.3 DC Electrical Specifications

Table 3 provides the DC electrical characteristics for the MPC107.

Table 3. DC Electrical Specifications

At recommended operating conditions (See Table 2)

Characteristics	Conditions [1]	Symbol	Min	Max	Unit	Notes
Input high voltage	PCI only	V_{IH}	$0.65 \times OV_{DD}$	LV_{DD}	V	2, 3
Input low voltage	PCI only	V_{IL}	—	$0.3 \times OV_{DD}$	V	
Input high voltage	All other pins (GV_{DD} = 3.3 V)	V_{IH}	2.0	—	V	2
	All other pins (BV_{DD} = 2.5 V)	V_{IH}	1.7	—	V	2
Input low voltage	All inputs except PCI_SYNC_IN	V_{IL}	GND	0.8	V	
PCI_SYNC_IN input high voltage		CV_{IH}	2.4	—	V	
PCI_SYNC_IN input low voltage		CV_{IL}	GND	0.4	V	
Input leakage current for pins using DRV_PCI driver	$0.5 V \le V_{in} \le 2.7 V$ @ LV_{DD} = 4.75 V	I_L	—	±70	µA	4
Input leakage current all others	LV_{DD} = 3.6 V ($GV_{DD} \le 3.465$ V)	I_L	—	±10	µA	4
Output high voltage	I_{OH} = driver dependent (GV_{DD} = 3.3 V)	V_{OH}	2.4	—	V	5
Output low voltage	I_{OL} = driver dependent (GV_{DD} = 3.3 V)	V_{OL}	—	0.4	V	5

Table 3. DC Electrical Specifications (continued)

At recommended operating conditions (See Table 2)

Characteristics	Conditions [1]	Symbol	Min	Max	Unit	Notes
Output high voltage	I_{OH} = driver dependent (BV_{DD} = 2.5 V) All outputs except CPU_CLK[0:2]	V_{OH}	1.85	—	V	5
	I_{OH} = driver dependent (BV_{DD} = 2.5 V) CPU_CLK[0:2] only	V_{OH}	2.0	—	V	5
Output low voltage	I_{OL} = driver dependent (BV_{DD} = 2.5 V) All outputs except CPU_CLK[0:2]	V_{OL}	—	0.4	V	5
	I_{OL} = driver dependent (BV_{DD} = 2.5 V) CPU_CLK[0:2] only	V_{OL}	—	0.3	V	5
Capacitance	V_{in} = 0 V, f = 1 MHz	C_{in}	—	7.0	pF	6

Notes:
1. These specifications are for the default driver strengths indicated in Table 4.
2. See Figure 17 for pins with internal pull-up resistors.
3. The minimum input high voltage is not compliant with the *PCI Local Bus Specification* (Rev 2.1), which specifies $0.5 \times OV_{DD}$ for minimum input high voltage.
4. Leakage current is measured on input and output pins in the high-impedance state. The leakage current is measured for nominal OV_{DD}/LV_{DD} and V_{DD} or both OV_{DD}/LV_{DD} and V_{DD} must vary in the same direction.
5. See Table 4 for the typical drive capability of a specific signal pin based on the type of output driver associated with that pin as listed in Table 17.
6. Capacitance is periodically sampled rather than 100% tested.

1.4.1.4 Output Driver Characteristics

Table 4 provides information on the characteristics of the output drivers referenced in Table 17. The values are from the MPC107 IBIS model (v1.1) and are not tested. For additional detailed information, see the complete IBIS model listing at http://www.motorola.com/semiconductors.

Table 4. Drive Capability of MPC107 Output Pins

Driver Type	Programmable Output Impedance (Ω)	Supply Voltage	I_{OH}	I_{OL}	Unit	Notes
DRV_CPU	20	BV_{DD} = 3.3 V	36.6	18.1	mA	2, 5
		BV_{DD} = 2.5 V	21.4	15.6	mA	3, 6, 7
	40 (default)	BV_{DD} = 3.3 V	18.6	9.2	mA	2, 5
		BV_{DD} = 2.5 V	10.8	7.9	mA	3, 6, 7
DRV_PCI	25	OV_{DD} = 3.3 V	12.0	12.4	mA	1, 4
	50 (default)	OV_{DD} = 3.3 V	6.1	6.3	mA	1, 4
DRV_CPU_CLK	8 (default)	GV_{DD} = 3.3 V	89.0	42.3	mA	2, 5
DRV_MEM_CTRL	13.3	GV_{DD} = 3.3 V	55.8	26.4	mA	2, 5
DRV_MEM_CLK	20	GV_{DD} = 3.3 V	36.6	18.1	mA	2, 5
DRV_PCI_CLK	40	GV_{DD} = 3.3 V	18.6	9.2	mA	2, 5
DRV_MEM_DATA	20 (default)	GV_{DD} = 3.3 V	36.6	18.1	mA	2, 5
	40	GV_{DD} = 3.3 V	18.6	9.2	mA	2, 5

Notes:
1. For DRV_PCI, I_{OH} read from the IBIS listing in the pull-up mode, I(Min) column, at the 0.33-V label by interpolating between the 0.3- and 0.4-V table entries' current values which corresponds to the PCI $V_{OH} = 2.97 = 0.9 \times OV_{DD}$ (OV_{DD} = 3.3 V), where table entry voltage = OV_{DD} – PCI V_{OH}.
2. For all others with GV_{DD} or BV_{DD} = 3.3 V, I_{OH} read from the IBIS listing in the pull-up mode, I(Min) column, at the 0.9-V table entry which corresponds to the V_{OH} = 2.4 V, where table entry voltage = G/BV_{DD} – V_{OH}.
3. For all others with BV_{DD} = 2.5 V, I_{OH} read from the IBIS listing in the pull-up mode, I(Min) column, at the 0.65-V table entry by interpolating between the 0.6- and 0.7-V table entries' current values which corresponds to the V_{OH} = 1.85 V, where table entry voltage = BV_{DD} – V_{OH}.
4. For DRV_PCI, I_{OL} read from the IBIS listing in the pull-down mode, I(Min) column, at 0.33 V = PCI $V_{OL} = 0.1 \times OV_{DD}$ (OV_{DD} = 3.3 V) by interpolating between the 0.3-and 0.4-V table entries.
5. For all others with GV_{DD} or BV_{DD} = 3.3 V, I_{OL} read from the IBIS listing in the pull-down mode, I(Min) column, at the 0.4-V table entry.
6. For all others with BV_{DD} = 2.5 V, I_{OL} read from the IBIS listing in the pull-down mode, I(Min) column, at the 0.4-V table entry.
7. For BV_{DD} = 2.5 V, the I_{OH} and I_{OL} values are estimated from the io_mem_data_XX_2.5 and io_mem_addr_XX_2.5 sections of the IBIS model, where XX = driver output impedance (20 or 40 Ω).

1.4.1.5 Power Characteristics

Table 5 provides the preliminary power consumption estimates for the MPC107. Power consumption on the PLL supply pin (AV_{DD}) and the DLL supply pin (LAV_{DD}) < 15 mW. This information is based on characterization data.

Table 5. Power Consumption

Mode	PCI_SYNC_IN/Core Frequency (MHz)								Unit	Notes
	25/50		33/33		33/66		66/100			
	V_{DD} Power	I/O Power	V_{DD} Power	I/O Power	V_{DD} Power	I/O Power	V_{DD} Power	I/O Power		
Typical	468	923	351	759	644	1087	933	1122	mW	1, 2
Doze	176	697	118	636	235	800	350	915	mW	1, 2
Nap	139	744	93	693	185	420	276	970	mW	1, 2
Sleep	79	718	45	677	102	841	138	939	mW	1, 2

Notes:
1. Power is measured with V_{DD} = 2.625 V, GV_{DD} = OV_{DD} = BV_{DD} = 3.45 V at 0°C and one DIMM populated in test system.
2. All clock drivers enabled.

1.4.1.6 Thermal Characteristics

Table 6 provides the package thermal characteristics for the MPC107. Refer to Section 1.7, “System Design Information,” for more details about thermal management.

Table 6. FC-PBGA Package Thermal Characteristics

Characteristic	Symbol	Value	Unit	Notes
Junction-to-ambient natural convection (Single-layer board—1s)	$R_{\theta JA}$	30	°C/W	1, 2
Junction-to-ambient natural convection (Four-layer board—2s2p)	$R_{\theta JMA}$	26	°C/W	1, 3
Junction-to-ambient (@200 ft/min) (Single-layer board—1s)	$R_{\theta JMA}$	25	°C/W	1, 3
Junction-to-ambient (@200 ft/min) (Four-layer board—2s2p)	$R_{\theta JMA}$	22	°C/W	1, 3
Junction-to-board	$R_{\theta JB}$	20	°C/W	4
Junction-to-case	$R_{\theta JC}$	<0.1	°C/W	5

Notes:
1. Junction temperature is a function of on-chip power dissipation, package thermal resistance, mounting site (board) temperature, ambient temperature, airflow, power dissipation of other components on the board, and board thermal resistance.
2. Per SEMI G38-87 and JEDEC JESD51-2 with the single-layer board horizontal.
3. Per JEDEC JESD51-6 with the board horizontal.
4. Thermal resistance between the die and the printed-circuit board per JEDEC JESD51-8. Board temperature is measured on the top surface of the board near the package.
5. Thermal resistance between the die and the case top surface without thermal grease.

1.4.2 AC Electrical Characteristics

This section provides the AC electrical characteristics for the MPC107. After fabrication, functional parts are sorted by maximum core frequency as shown in Table 7 and Section 1.4.2.1, “Clock AC Specifications,” and tested for conformance to the AC specifications for that frequency. The core frequency is determined by the bus (PCI_SYNC_IN) clock frequency and the settings of the PLL_CFG[0:3] signals. Parts are sold by maximum processor core frequency; see Section 1.9, “Ordering Information.”

Table 7 provides the operating frequency information for the MPC107.

Table 7. Operating Frequency [1]

At recommended operating conditions (See Table 2) with LV_{DD} = 3.3 V ± 0.3 V

Characteristic [2]	66 MHz		100 MHz		Unit
	Min	Max	Min	Max	
Core (memory bus/processor bus) frequency	25	66	25	100	MHz
PCI input frequency (PCI_SYNC_IN)	12.5–66				MHz

Notes:
1. See Section 1.9.2, “Part Numbers Not Fully Addressed by This Document,” for information on the 133-MHz part offering.
2. The PCI_SYNC_IN frequency and PLL_CFG[0:3] settings must be chosen such that the resulting peripheral logic/memory bus frequency, CPU (core) frequency, and PLL (VCO) frequencies do not exceed their respective maximum or minimum operating frequencies. Refer to the PLL_CFG[0:3] signal description in Section 1.6, “PLL Configuration,” for valid PLL_CFG[0:3] settings and PCI_SYNC_IN frequencies.

1.4.2.1 Clock AC Specifications

Table 8 provides the clock AC timing specifications as defined in Section 1.4.2.2, “Input AC Timing Specifications.” These specifications are for the default driver strengths indicated in Table 4.

Table 8. Clock AC Timing Specifications

At recommended operating conditions (See Table 2) with LV_{DD} = 3.3 V ± 0.3 V

Num	Characteristics and Conditions	Min	Max	Unit	Notes
1a	Frequency of operation (PCI_SYNC_IN)	12.5	66	MHz	7
1b	PCI_SYNC_IN cycle time	80	15	ns	7
2,3	PCI_SYNC_IN rise and fall times	—	2.0	ns	1
4	PCI_SYNC_IN duty cycle measured at 1.4 V	40	60	%	
5a	PCI_SYNC_IN pulse width high measured at 1.4 V	6	9	ns	2
5b	PCI_SYNC_IN pulse width low measured at 1.4 V	6	9	ns	2
7	PCI_SYNC_IN jitter	—	<150	ps	
9a	PCI_CLK[0:4] skew (pin-to-pin)	—	500	ps	
9b	SDRAM_CLK[0:3] skew (pin-to-pin)	—	350	ps	
9c	CPU_CLK[0:2] skew (pin-to-pin)	—	350	ps	
9d	SDRAM_CLK[0:3]/CPU_CLK[0:2] jitter	—	150	ps	
10	Internal PLL relock time	—	100	µs	2, 3, 5

Table 8. Clock AC Timing Specifications (continued)

At recommended operating conditions (See Table 2) with LV_{DD} = 3.3 V ± 0.3 V

Num	Characteristics and Conditions	Min	Max	Unit	Notes
15	DLL lock range with DLL_STANDARD = 1 (default)	See Figure 8		ns	6
16	DLL lock range with DLL_STANDARD = 0	See Figure 9		ns	6
17	Frequency of operation (OSC_IN)	12.5	66	MHz	7
18	OSC_IN cycle time	80	15	ns	7
19	OSC_IN rise and fall times	—	5	ns	4
20	OSC_IN duty cycle measured at 1.4 V	40	60	%	
21	OSC_IN frequency stability	—	100	ppm	

Notes:
1. Rise and fall times for the PCI_SYNC_IN input are measured from 0.4 to 2.4 V.
2. Specification value at maximum frequency of operation.
3. Relock time is guaranteed by design and characterization. Relock time is not tested.
4. Rise and fall times for the OSC_IN input are guaranteed by design and characterization. OSC_IN input rise and fall times are not tested.
5. Relock timing is guaranteed by design. PLL-relock time is the maximum amount of time required for PLL lock after a stable V_{DD} and PCI_SYNC_IN are reached during the reset sequence. This specification also applies when the PLL has been disabled and subsequently re-enabled during sleep mode. Also note that $\overline{\text{HRESET}}$ must be held asserted for a minimum of 255 bus clocks after the PLL-relock time during the reset sequence.
6. DLL_STANDARD is bit 7 of the PMC2 register <72>. N is a non-zero integer (1 or 2). T_{clk} is the period of one SDRAM_SYNC_OUT clock cycle in ns. t_{loop} is the propagation delay of the DLL synchronization feedback loop (PC board runner) from SDRAM_SYNC_OUT to SDRAM_SYNC_IN in ns; 6.25 inches of loop length (unloaded PC board runner) corresponds to approximately 1 ns of delay. See Figure 8 and Figure 9 for DLL locking ranges.
7. See Table 18 for PCI_SYNC_IN input frequency range for specific PLL_CFG[0:3] settings.

Figure 6 shows PCI_SYNC_IN input clock timing, Figure 7 illustrates how the clock specifications in Table 8 relate to the MPC107 clocking. Figure 8 and Figure 9 shows the DLL locking range loop delay.

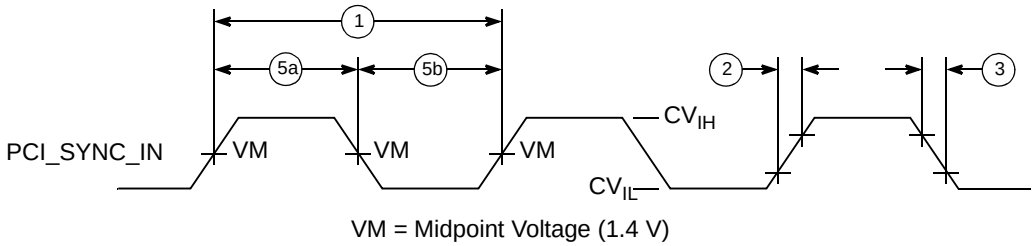
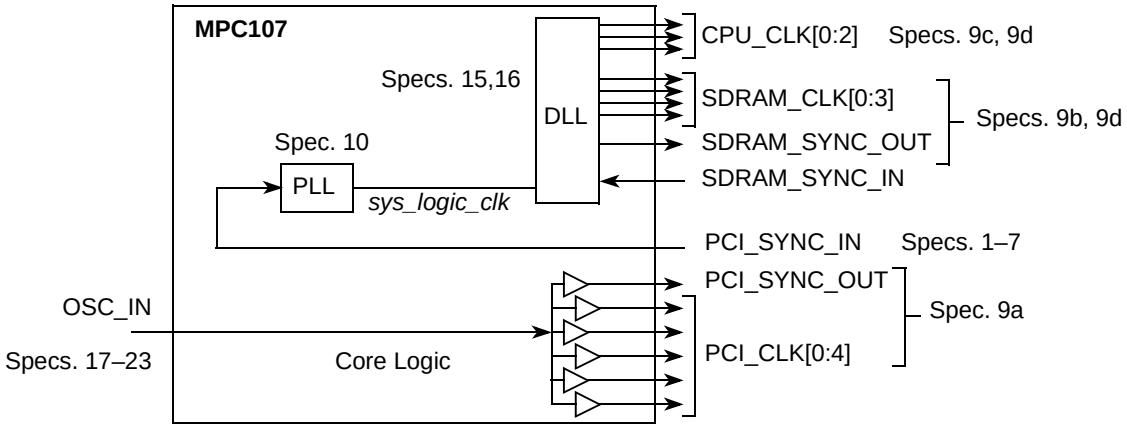


Figure 6. PCI_SYNC_IN Input Clock Timing Diagram



Note: Specification numbers are from Table 8.

Figure 7. Clock Subsystem Block Diagram

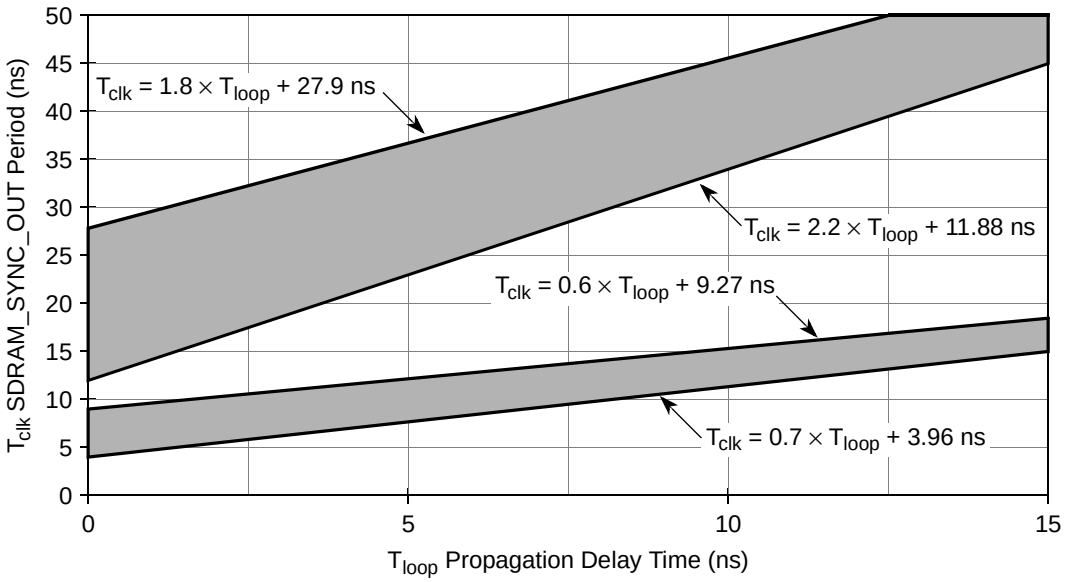


Figure 8. DLL Locking Range Loop Delay (DLL_STANDARD = 0)

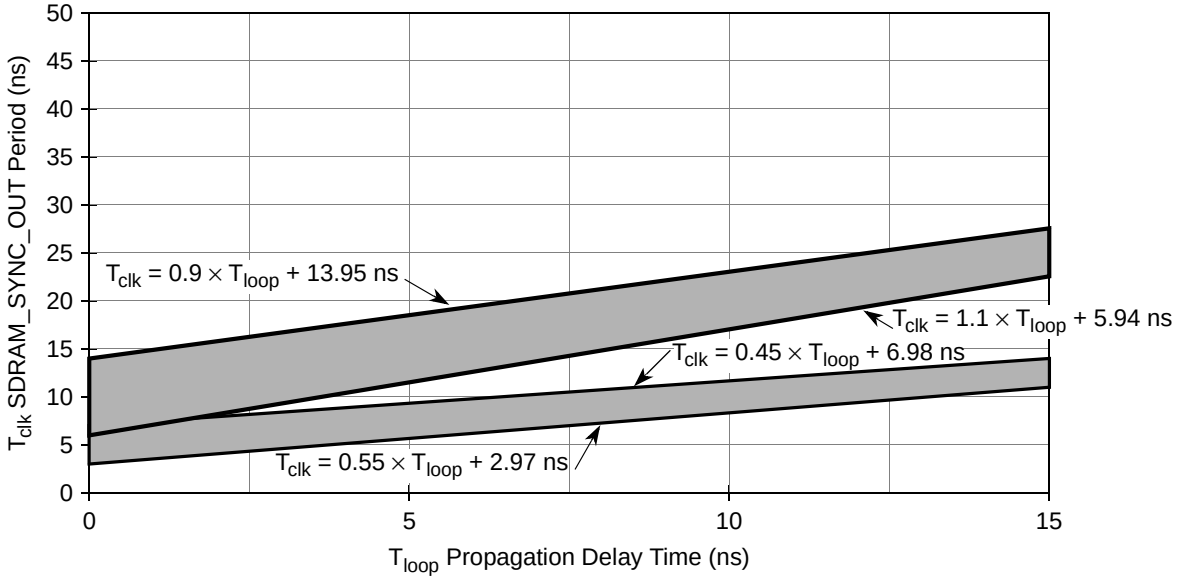


Figure 9. DLL Locking Range Loop Delay (DLL_STANDARD = 1)

1.4.2.2 Input AC Timing Specifications

Table 9 provides the input AC timing specifications. See Figure 10 and Figure 11.

Table 9. Input AC Timing Specifications

At recommended operating conditions (see Table 2) with LV_{DD} = 3.3 V ± 0.3 V

Num	Characteristic	Min	Max	Unit	Notes
10a	PCI input signals valid to PCI_SYNC_IN (input setup)	3.0	—	ns	2, 3
10b	Memory interface signals valid to SDRAM_SYNC_IN (input setup)	2.0	—	ns	1, 3
10c	PIC, misc. debug input signals valid to SDRAM_SYNC_IN (input setup)	2.0	—	ns	1, 3
10d	I^2C input signals valid to SDRAM_SYNC_IN (input setup)	2.0	—	ns	1, 3
10e	Mode select inputs valid to $\overline{\text{HRESET}}$ (input setup)	$9 \times t_{CLK}$	—	ns	3, 4, 5
10f	60x processor interface signals valid to SDRAM_SYNC_IN (input setup)	2.0	—	ns	1, 3
11a1	PCI_SYNC_IN (SDRAM_SYNC_IN) to inputs invalid (input hold)	1.0	—	ns	2, 3
11a2	Memory interface signals SDRAM_SYNC_IN to inputs invalid (input hold)	0.5	—	ns	1, 3
11a3	60x processor interface signals SDRAM_SYNC_IN to inputs invalid (input hold)	0	—	ns	1, 3
11b	$\overline{\text{HRESET}}$ to mode select inputs invalid (input hold)	0	—	ns	1, 3, 5

Notes:
1. All memory, processor, and related interface input signal specifications are measured from the TTL level (0.8 or 2.0 V) of the signal in question to the VM = 1.4 V of the rising edge of the memory bus clock, SDRAM_SYNC_IN. SDRAM_SYNC_IN is the same as PCI_SYNC_IN in 1:1 mode, but is twice the frequency in 2:1 mode (processor/memory bus clock rising edges occur on every rising and falling edge of PCI_SYNC_IN). See Figure 10.
2. All PCI signals are measured from $OV_{DD}/2$ of the rising edge of PCI_SYNC_IN to $0.4 \times OV_{DD}$ of the signal in question for 3.3-V PCI signaling levels. See Figure 11.
3. Input timings are measured at the pin.
4. t_{CLK} is the time of one SDRAM_SYNC_IN clock cycle.
5. All mode select input signal specifications are measured from the TTL level (0.8 or 2.0 V) of the signal in question to the VM = 1.4 V of the rising edge of the $\overline{\text{HRESET}}$ signal. See Figure 12.

Figure 10 shows input-output timing referenced to SDRAM_SYNC_IN and Figure 11 the input-output timing referenced to PCI_SYNC_IN.

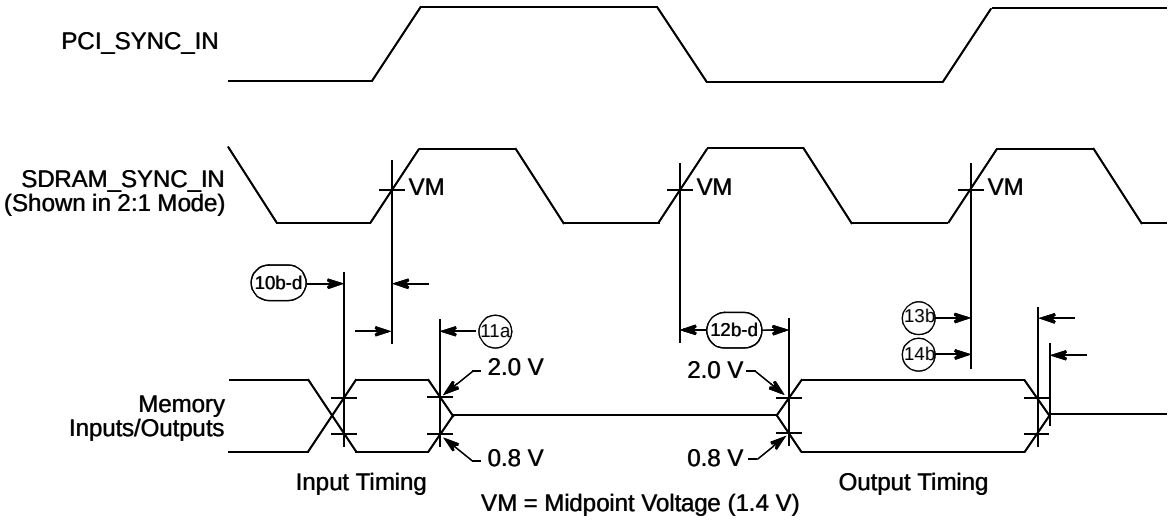


Figure 10. Input-Output Timing Diagram Referenced to SDRAM_SYNC_IN

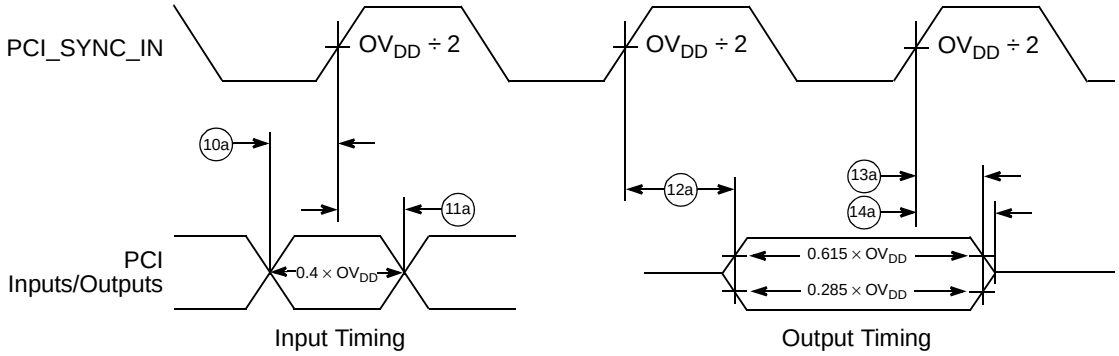


Figure 11. Input-Output Timing Diagram Referenced to PCI_SYNC_IN

Figure 12 shows input timing for mode select signals.

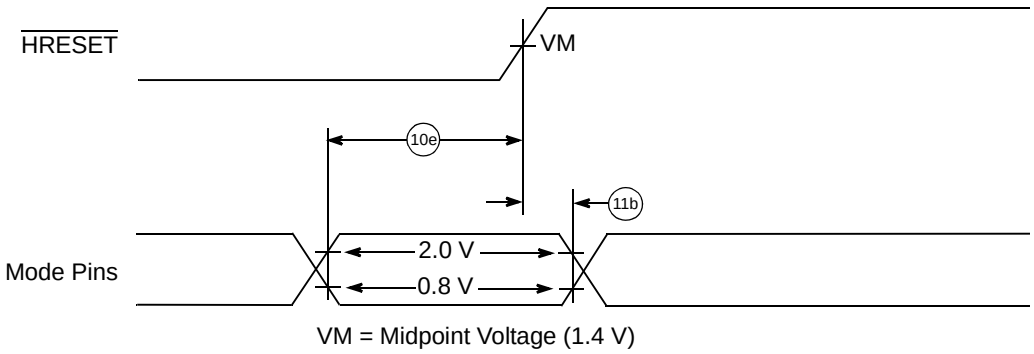


Figure 12. Input Timing Diagram for Mode Select Signals

1.4.2.3 Output AC Timing Specification

Table 10 provides the processor bus AC timing specifications for the MPC107. See Figure 10 and Figure 11.

Table 10. Output AC Timing Specifications

At recommended operating conditions (see Table 2) with LV_{DD} = 3.3 V ± 0.3 V

Num	Characteristic [3, 6]	Min	Max	Unit	Notes
12a	PCI_SYNC_IN to output valid, 66 MHz PCI, with SDMA4 pulled-down to logic 0 state (see Figure 11)	—	6.0	ns	2, 4
	PCI_SYNC_IN to output valid, 33 MHz PCI, with SDMA4 in the default logic 1 state (see Figure 11)	—	11.0	ns	2, 4
12b	Memory interface signals, SDRAM_SYNC_IN to output valid	—	5.5	ns	1
12b1	Memory interface signal, CKE (100-MHz device), SDRAM_SYNC_IN to output valid	—	5.5	ns	1
12b2	Memory interface signal, CKE (66-MHz device), SDRAM_SYNC_IN to output valid	—	6.0	ns	1
12c	PIC, misc. debug signals, SDRAM_SYNC_IN to valid	—	9.0	ns	1
12d	I^2C, SDRAM_SYNC_IN to output valid	—	5.0	ns	1
12e	60x Processor interface signals, SDRAM_SYNC_IN to output valid	—	5.5	ns	1
13a	Output hold, 66 MHz PCI, with SDMA4 and SDMA3 pulled down to logic 0 states (see Table 11)	1.0	—	ns	2, 4, 5
	Output hold, 33 MHz PCI, with SDMA4 in the default logic 1 state and SDMA3 pulled down to logic 0 state (see Table 11)	2.0	—	ns	2, 4, 5
13b	Output hold (for all others)	1	—	ns	1
14a	PCI_SYNC_IN to output high impedance (T_{off} for PCI)	—	14.0	ns	2, 4
14b	SDRAM_SYNC_IN to output high impedance (for all others)	—	4.0	ns	1

Notes:

1. All memory and related interface output signal specifications are specified from the VM = 1.4 V of the rising edge of the memory bus clock, SDRAM_SYNC_IN to the TTL level (0.8 or 2.0 V) of the signal in question. SDRAM_SYNC_IN is the same as PCI_SYNC_IN in 1:1 mode, but is twice the frequency in 2:1 mode (processor/memory bus clock rising edges occur on every rising and falling edge of PCI_SYNC_IN). See Figure 10.
2. All PCI signals are measured from $OV_{DD}/2$ of the rising edge of PCI_SYNC_IN to 0.285*OV_{DD} or 0.615*OV_{DD} of the signal in question for 3.3-V PCI signaling levels. See Figure 11.
3. All output timings assume a purely resistive 50-Ω load (see Figure 13). Output timings are measured at the pin; time-of-flight delays must be added for trace lengths, vias, and connectors in the system.
4. PCI bused signals are composed of the following signals: $\overline{\text{LOCK}}$, $\overline{\text{IRDY}}$, $\overline{\text{C/BE}}$[0:3], PAR, $\overline{\text{TRDY}}$, $\overline{\text{FRAME}}$, $\overline{\text{STOP}}$, $\overline{\text{DEVSEL}}$, $\overline{\text{PERR}}$, $\overline{\text{SERR}}$, AD[0:31], $\overline{\text{REQ}}$[4:0], $\overline{\text{GNT}}$[4:0], $\overline{\text{IDSEL}}$, and $\overline{\text{INTA}}$.
5. PCI hold times can be varied; see Section 1.4.2.4, “PCI Signal Output Hold Timing,” for information on programmable PCI output hold times. The values shown for item 13a are for PCI compliance.
6. These specifications are for the default driver strengths indicated in Table 4.

Figure 13 shows the AC test load for the MPC107.

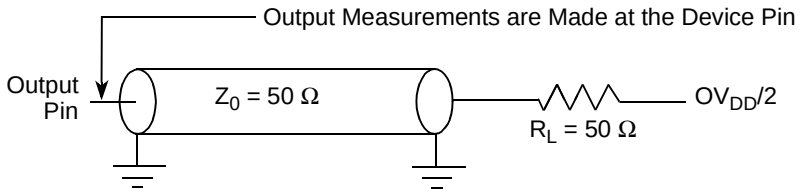


Figure 13. AC Test Load for the MPC107

1.4.2.4 PCI Signal Output Hold Timing

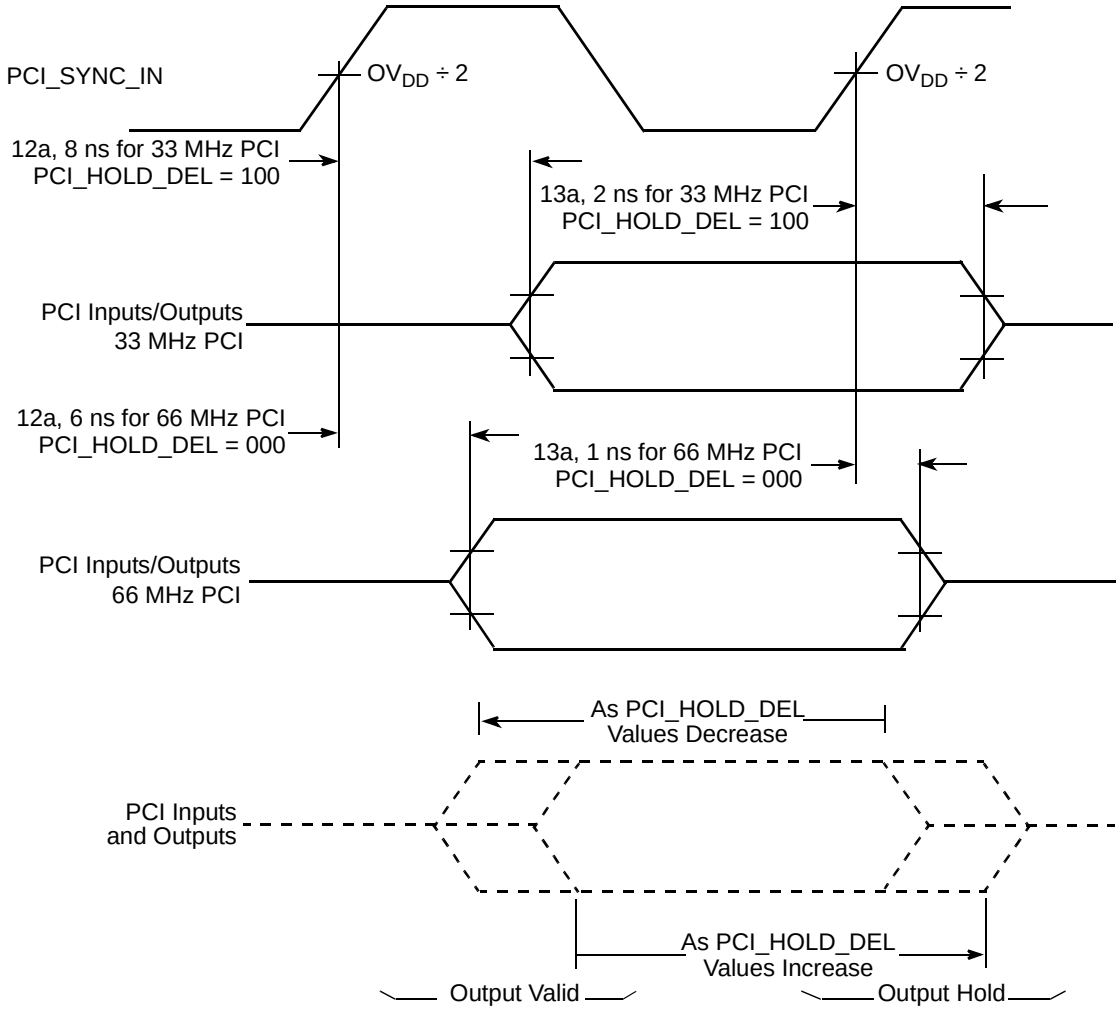
In order to meet minimum output hold specifications relative to PCI_SYNC_IN for both 33 and 66 MHz PCI systems, the MPC107 has a programmable output hold delay for PCI signals. The initial value of the output hold delay is determined by the values on the SDMA4 and SDMA3 reset configuration signals. Further output hold delay values are available by programming the PCI_HOLD_DEL value of the PMCR2 configuration register.

Table 11 describes the bit values for the PCI_HOLD_DEL values in PMCR2.

Table 11. Power Management Configuration Register 2—0x72

Bit	Name	Reset Value	Description
6–4	PCI_HOLD_DEL	xx0	PCI output hold delay values relative to PCI_SYNC_IN. The initial values of bits 6 and 5 are determined by the reset configuration pins SDMA4 and SDMA3, respectively. As these two pins have internal pull-up resistors, the default value after reset is 0b110. While the minimum hold times are guaranteed at shown values, changes in the actual hold time can be made by incrementing or decrementing the value in these bit fields of this register via software or hardware configuration. The increment is in approximately 400-picosecond steps. Lowering the value in the 3-bit field decreases the amount of output hold available. 000 66 MHz PCI. Pull-down SDMA4 configuration pin with a 2-kΩ or less value resistor. This setting guarantees the minimum output hold (item 13a) and the maximum output valid (item 12a) times as specified in Figure 10 are met for a 66-MHz PCI system. See Figure 14. 001 010 011 100 33 MHz PCI. This setting guarantees the minimum output hold (item 13a) and the maximum output valid (item 12a) times as specified in Figure 10 are met for a 33-MHz PCI system. See Figure 14. 101 110 (Default if reset configuration pins left unconnected) 111

Figure 14 shows the PCI_HOLD_DEL effect on output valid and hold time.



Note: Diagram not to scale.

Figure 14. PCI_HOLD_DEL Effect on Output Valid and Hold Time

1.4.2.5 I^2C AC Timing Specifications

Table 12 provides the I^2C input AC timing specifications for the MPC107.

Table 12. I^2C Input AC Timing Specifications

At recommended operating conditions (see Table 2) with LV_{DD} = 3.3 V ± 0.3 V

Num	Characteristic	Min	Max	Unit	Notes
1	Start condition hold time	4.0	—	CLKs	1, 2
2	Clock low period (the time before MPC107 will drive SCL low as a transmitting slave after detecting SCL low as driven by an external master)	$8.0 + (16 \times 2^{FDR[4:2]}) \times (5 - 4(\{FDR[5],FDR[1]\} == b'10) - 3(\{FDR[5],FDR[1]\} == b'11) - 2(\{FDR[5],FDR[1]\} == b'00) - 1(\{FDR[5],FDR[1]\} == b'01))$	—	CLKs	1, 2, 4, 5
3	SCL/SDA rise time (from 0.5 to 2.4 V)	—	1	ms	
4	Data hold time	0	—	ns	2
5	SCL/SDA fall time (from 2.4 to 0.5 V)	—	1	ms	
6	Clock high period (time needed to either receive a data bit or generate a START or STOP)	5.0	—	CLKs	1, 2, 5
7	Data setup time	3.0	—	ns	3
8	Start condition setup time (for repeated start condition only)	4.0	—	CLKs	1, 2
9	Stop condition setup time	4.0	—	CLKs	1, 2

Notes:
1. Units for these specifications are in SDRAM_CLK/CPU_CLK units.
2. The actual values depend on the setting of the digital filter frequency sampling rate (DFFSR) bits in the frequency divider register I2CFDR. Therefore, the noted timings in this table are all relative to qualified signals. The qualified SCL and SDA are delayed signals from what is seen in real time on the I^2C bus. The qualified SCL, SDA signals are delayed by the SDRAM_CLK/CPU_CLK clock times DFFSR times two plus one SDRAM_CLK/CPU_CLK clock. The resulting delay value is added to the value in this table (where this note is referenced). See Figure 16.
3. Timing is relative to the sampling clock (not SCL).
4. FDR[*n*] refers to the frequency divider register (FDR) I2CFDR bit *n*.
5. Input clock low and high periods in combination with the FDR value in the frequency divider register (I2CFDR) determine the maximum I^2C input frequency. See Figure 13.

Table 13 provides the I^2C frequency divider register (I2CFDR) information for the MPC107.

Table 13. MPC107 Maximum I^2C Input Frequency

FDR Hex [2]	Divider [3] (Dec)	Maximum I^2C Input Frequency [1]			
		SDRAM_CLK/ CPU_CLK @ 25 MHz	SDRAM_CLK/ CPU_CLK @ 33 MHz	SDRAM_CLK/ CPU_CLK @ 50 MHz	SDRAM_CLK/ CPU_CLK @ 100 MHz
20, 21	160, 192	862	1.13 MHz	1.72 MHz	3.44 MHz
22, 23, 24, 25	224, 256, 320, 384	555	733	1.11 MHz	2.22 MHz
0, 1	288, 320	409	540	819	1.63 MHz
2, 3, 26, 27, 28, 29	384, 448, 480, 512, 640, 768	324	428	649	1.29 MHz
4, 5	576, 640	229	302	458	917
6, 7, 2A, 2B, 2C, 2D	768, 896, 960, 1024, 1280, 1536	177	234	354	709
8, 9	1152, 1280	121	160	243	487
A, B, 2E, 2F, 30, 31	1536, 1792, 1920, 2048, 2560, 3072	92	122	185	371
C, D	2304, 2560	62	83	125	251
E, F, 32, 33, 34, 35	3072, 3584, 3840, 4096, 5120, 6144	47	62	95	190
10, 11	4608, 5120	32	42	64	128
12, 13, 36, 37, 38, 39	6144, 7168, 7680, 8192, 10240, 12288	24	31	48	96
14, 15	9216, 10240	16	21	32	64
16, 17, 3A, 3B, 3C, 3D	12288, 14336, 15360, 16384, 20480, 24576	12	16	24	48
18, 19	18432, 20480	8	10	16	32
1A, 1B, 3E, 3F	24576, 28672, 30720, 32768	6	8	12	24
1C, 1D	36864, 40960	4	5	8	16
1E, 1F	49152, 61440	3	4	6	12

Notes:
1. Values are in kHz, unless otherwise specified.
2. FDR Hex and Divider (Dec) values are listed in corresponding order.
3. Multiple Divider (Dec) values will generate the same input frequency, but each Divider (Dec) value will generate a unique output frequency as shown in Table 14.

Table 14 provides the I^2C output AC timing specifications for the MPC107.

Table 14. I^2C Output AC Timing Specifications

At recommended operating conditions (see Table 2) with LV_{DD} = 3.3 V ± 0.3 V

Num	Characteristic	Min	Max	Unit	Notes
1	Start condition hold time	(FDR[5] == 0) × (D_{FDR}/16)/2N + (FDR[5] == 1) × (D_{FDR}/16)/2M	—	CLKs	1, 2, 5
2	Clock low period	D_{FDR}/2	—	CLKs	1, 2, 5
3	SCL/SDA rise time (from 0.5 to 2.4 V)	—	—	ms	3
4	Data hold time	8.0 + (16 × $2^{FDR[4:2]}$) × (5 – 4({FDR[5],FDR[1]} == b'10)– 3({FDR[5],FDR[1]} == b'11) – 2({FDR[5],FDR[1]} == b'00) – 1({FDR[5],FDR[1]} == b'01))	—	CLKs	1, 2, 5
5	SCL/SDA fall time (from 2.4 to 0.5 V)	—	<5	ns	4
6	Clock high time	D_{FDR}/2	—	CLKs	1, 2, 5
7	Data setup time (MPC107 as a master only)	(D_{FDR}/2) – (Output data hold time)	—	CLKs	1, 5
8	Start condition setup time (for repeated start condition only)	D_{FDR} + (Output start condition hold time)	—	CLKs	1, 2, 5
9	Stop condition setup time	4.0	—	CLKs	1, 2

Notes:
1. Units for these specifications are in SDRAM_CLK/CPU_CLK units.
2. The actual values depend on the setting of the digital filter frequency sampling rate (DFFSR) bits in the frequency divider register I2CFDR. Therefore, the noted timings in this table are all relative to qualified signals. The qualified SCL and SDA are delayed signals from what is seen in real time on the I^2C bus. The qualified SCL, SDA signals are delayed by the SDRAM_CLK/CPU_CLK clock times DFFS times two plus one SDRAM_CLK/CPU_CLK clock. The resulting delay value is added to the value in this table where this note is referenced). See Figure 16.
3. Since SCL and SDA are open-drain type outputs, which the MPC107 can only drive low, the time required for SCL or SDA to reach a high level depends on external signal capacitance and pull-up resistor values.
4. Specified at a nominal 50 pF load.
5. D_{FDR} is the decimal divider number indexed by FDR[5:0] value. Refer to the I^2C Interface chapter's serial bit clock frequency divider selections table. FDR[*n*] refers to the frequency divider register I2CFDR bit *n*. N is equal to a variable number that would make the result of the divide (data hold time value) equal to a number less than 16. M is equal to a variable number that would make the result of the divide (data hold time value) equal to a number less than 9.

Figure 15 through Figure 18 show I^2C timings.

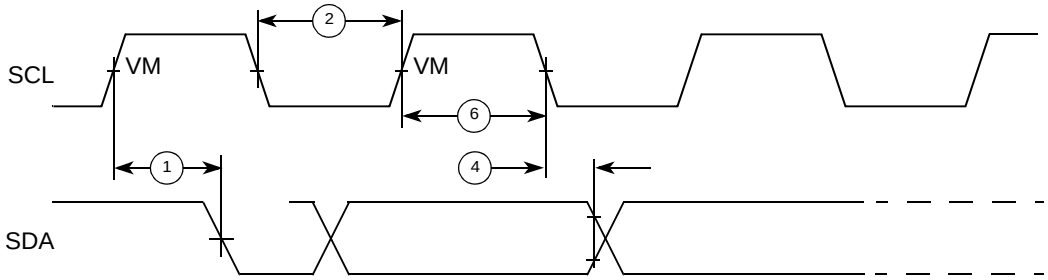


Figure 15. I^2C Timing Diagram I

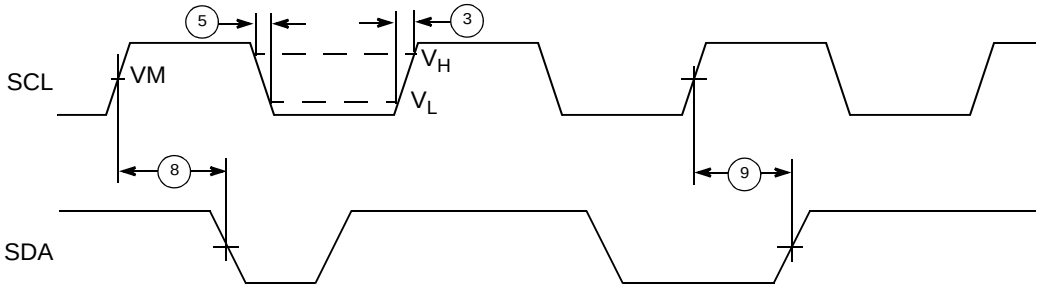
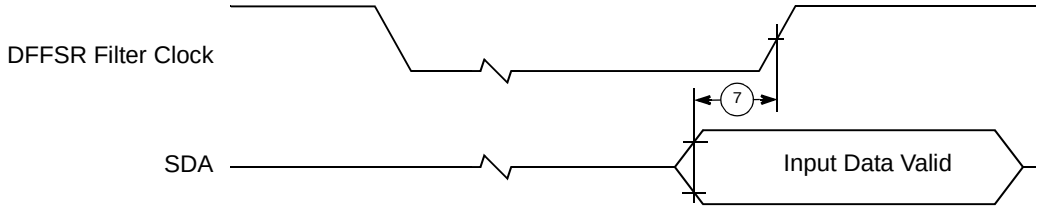
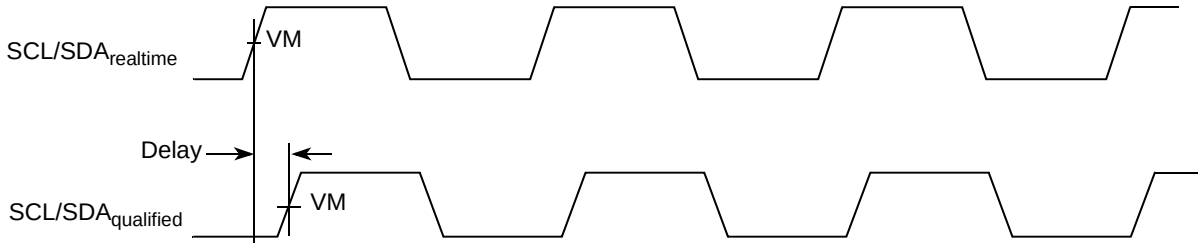


Figure 16. I^2C Timing Diagram II



Note: DFFSR filter clock is the SDRAM_CLK/CPU_CLK clock times DFFSR value.

Figure 17. I^2C Timing Diagram III



Note: The delay is the local memory clock times DFFSR times two plus one local memory clock.

Figure 18. I^2C Timing Diagram IV (Qualified Signal)

1.4.2.6 PIC Serial Interrupt Mode AC Timing Specifications

Table 15 provides the PIC serial interrupt mode AC timing specifications for the MPC107.

Table 15. PIC Serial Interrupt Mode AC Timing Specifications

At recommended operating conditions (see Table 2) with LV_{DD} = 3.3 V ± 0.3 V

Num	Characteristic	Min	Max	Unit	Notes
1	S_CLK frequency	1/14 SDRAM_SYNC_IN	1/2 SDRAM_SYNC_IN	MHz	1
2	S_CLK duty cycle	40	60	%	
3	S_CLK output valid time	—	6	ns	
4	Output hold time	0	—	ns	
5	$\overline{\text{S\_FRAME}}$, S_RST output valid time	—	1 *sys_logic_clk* period + 6	ns	2
6	S_INT input setup time to S_CLK	1 *sys_logic_clk* period + 2	—	ns	2
7	S_INT inputs invalid (hold time) to S_CLK	—	0	ns	2

Notes:
1. See the *MPC107 PCI Bridge/Memory Controller User's Manual* for a description of the PIC interrupt control register (ICR) describing S_CLK frequency programming.
2. S_RST, $\overline{\text{S\_FRAME}}$, and S_INT shown in Figure 19 and Figure 20 depict timing relationships to *sys_logic_clk* and S_CLK and do not describe functional relationships between S_RST, $\overline{\text{S\_FRAME}}$, and S_INT. See the *MPC107 PCI Bridge/Memory Controller User's Manual* for a complete description of the functional relationships between these signals.
3. The *sys_logic_clk* waveform is the clocking signal of the internal peripheral logic from the output of the peripheral logic PLL; *sys_logic_clk* is the same as SDRAM_SYNC_IN when the SDRAM_SYNC_OUT to SDRAM_SYNC_IN feedback loop is implemented and the DLL is locked. See the *MPC107 PCI Bridge/Memory Controller User's Manual* for a complete clocking description.

Figure 18 and Figure 19 show the PIC serial interrupt mode output and input timing diagrams, respectively.

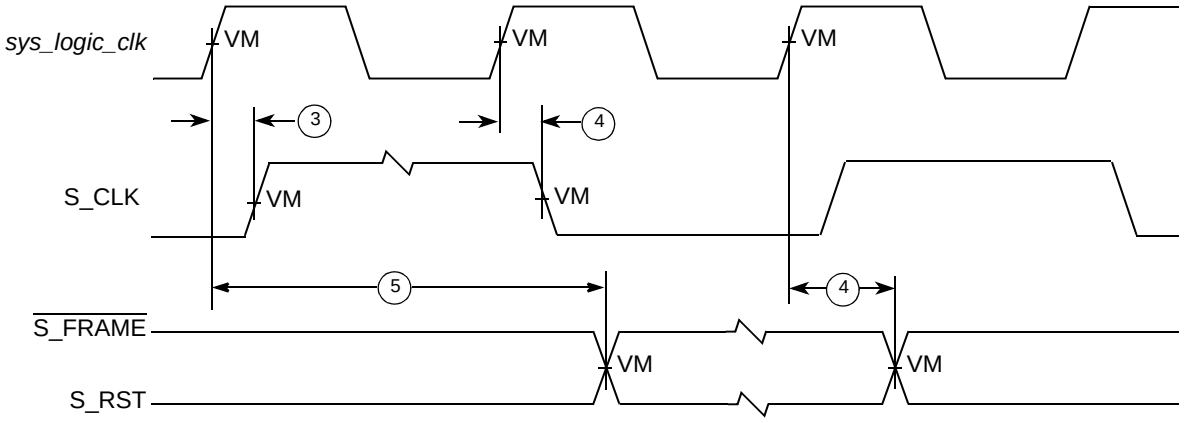


Figure 19. PIC Serial Interrupt Mode Output Timing Diagram

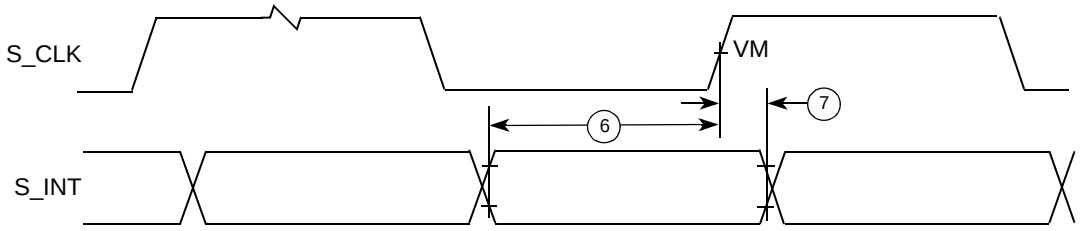


Figure 20. PIC Serial Interrupt Mode Input Timing Diagram

1.4.2.7 IEEE 1149.1 (JTAG) AC Timing Specifications

Table 16 provides the JTAG AC timing specifications for the MPC107 while in the JTAG operating mode.

Table 16. JTAG AC Timing Specification (Independent of PCI_SYNC_IN)

At recommended operating conditions (see Table 2) with LV_{DD} = 3.3 V ± 0.3 V

Num	Characteristic [1]	Min	Max	Unit	Notes
	TCK frequency of operation	0	25	MHz	
1	TCK cycle time	40	—	ns	
2	TCK clock pulse width measured at 1.5 V	20	—	ns	
3	TCK rise and fall times	0	3	ns	
4	$\overline{\text{TRST}}$ setup time to TCK falling edge	10	—	ns	2
5	$\overline{\text{TRST}}$ assert time	10	—	ns	
6	Boundary scan input data setup time	5	—	ns	3
7	Boundary scan input data hold time	15	—	ns	3
8	TCK to output data valid	0	30	ns	4
9	TCK to output high impedance	0	30	ns	4
10	TMS, TDI data setup time	5	—	ns	
11	TMS, TDI data hold time	15	—	ns	
12	TCK to TDO data valid	0	15	ns	
13	TCK to TDO high impedance	0	15	ns	

Notes:
1. Timings are independent of the system clock (PCI_SYNC_IN).
2. $\overline{\text{TRST}}$ is an asynchronous signal. The setup time is for test purposes only.
3. Non-test (other than TDI and TMS) signal input timing with respect to TCK.
4. Non-test (other than TDO) signal output timing with respect to TCK.

Figure 21 shows the JTAG clock input timing diagram.

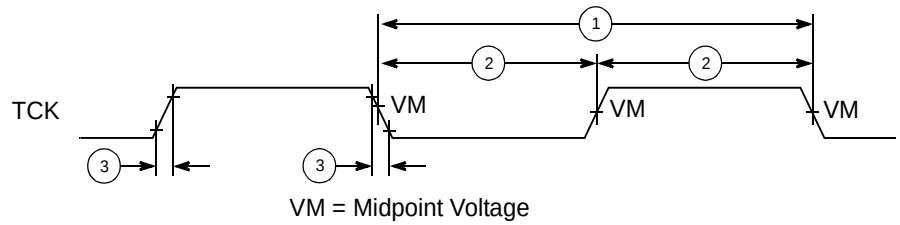


Figure 21. JTAG Clock Input Timing Diagram

Figure 22 shows the JTAG $\overline{\text{TRST}}$ timing diagram.

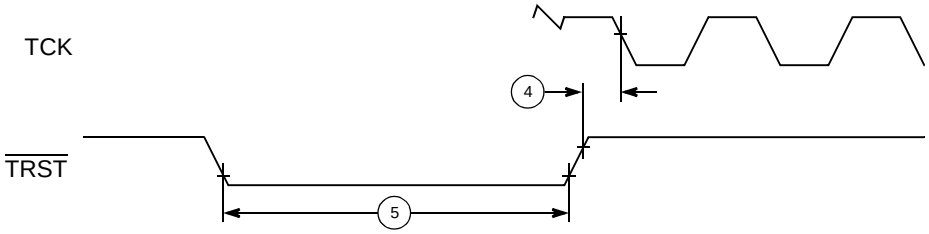


Figure 22. JTAG TRST Timing Diagram

Figure 23 shows the JTAG boundary scan timing diagram.

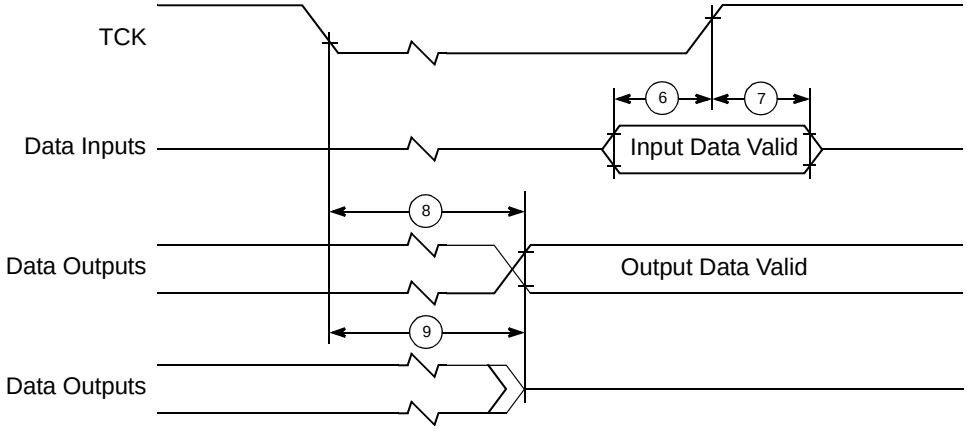


Figure 23. JTAG Boundary Scan Timing Diagram

Figure 24 shows the test access port timing diagram.

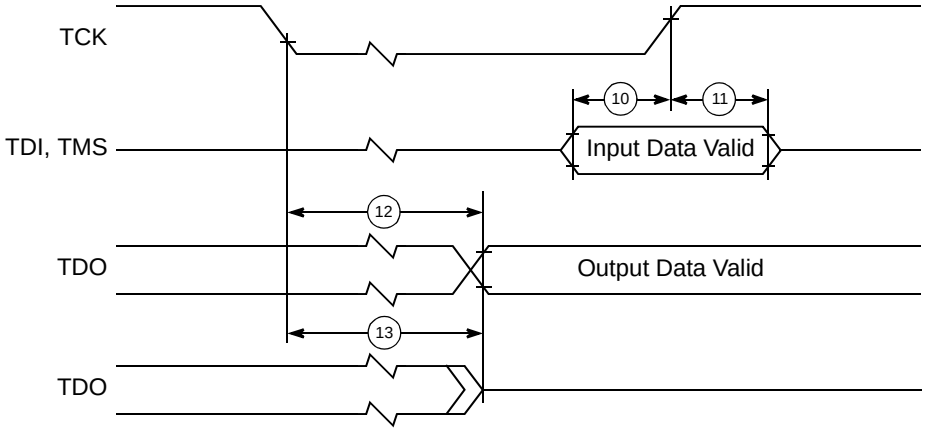


Figure 24. Test Access Port Timing Diagram

1.5 Package Description

This section details the MPC107 package parameters, pin assignments, and dimensions.

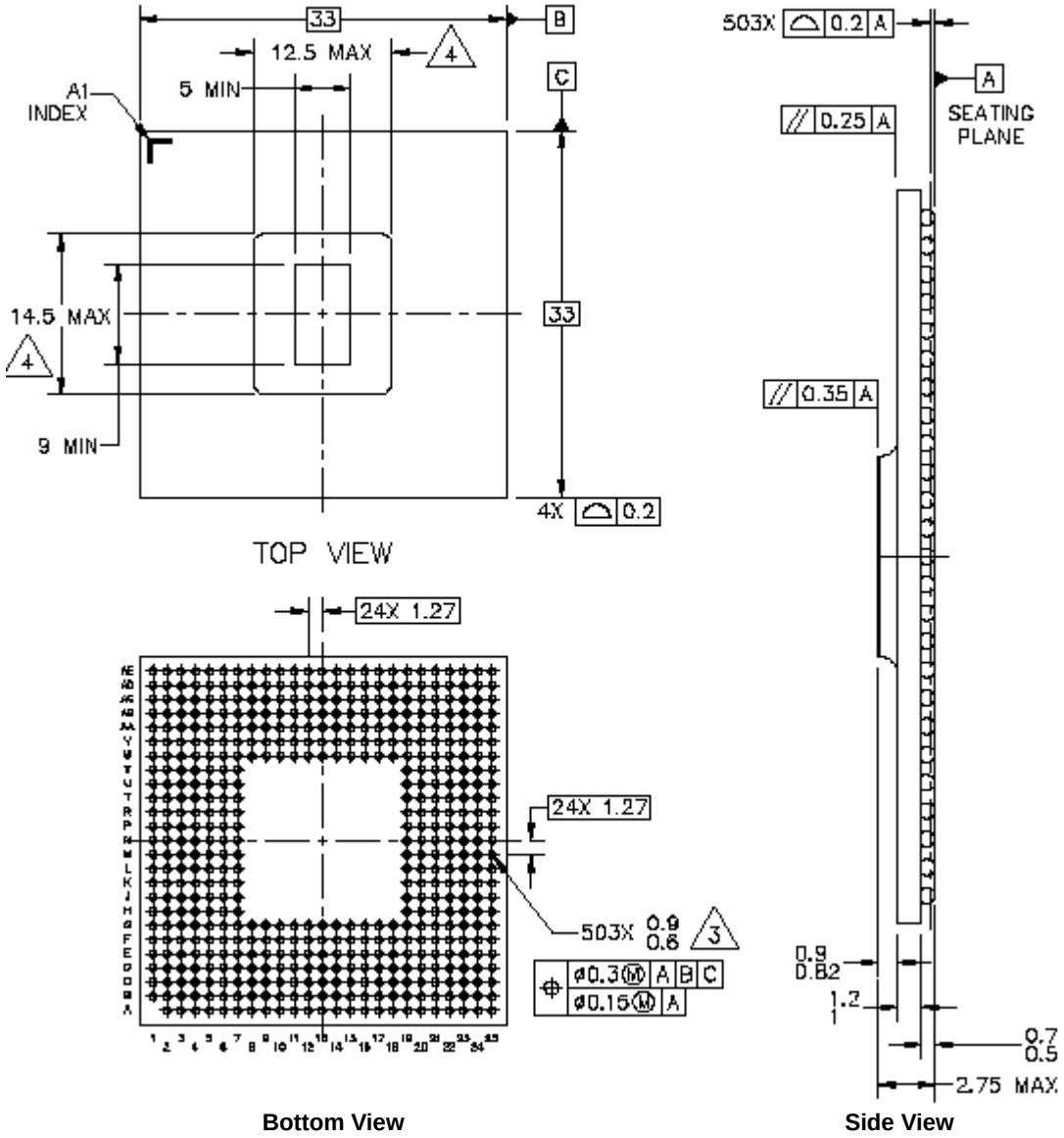
1.5.1 Package Parameters

The MPC107 uses a 33 mm × 33 mm, 503-pin flip chip plastic ball grid array (FC-PBGA) package. The plastic package parameters are as provided in the following list.

Package outline	33 mm × 33 mm
Interconnects	503
Pitch	1.27 mm
Solder attach	62 Sn/36 Pb/2 Ag
Solder balls	62 Sn/36 Pb/2 Ag
Solder ball diameter	0.60–0.90 mm
Maximum module height	2.75 mm
Co-planarity specification	0.20 mm
Maximum force	6.0 lbs. total, uniformly distributed over package (5.4 grams/ball)

1.5.2 Pin Assignments and Package Dimensions

Figure 25 shows the top surface, side profile, and pinout for the MPC107, 503 FC-PBGA package.



	MILLIMETERS	
DIM	MIN	MAX
A	—	2.75
A1	0.50	0.70
A2	1.00	1.20
A3	—	0.80
A4	0.82	0.90
b	0.60	0.90
D	33 BSC	
D1	30.48 BSC	
D2	—	12.50
D3	3.43	—
D4	5.00	—
e	1.27 BSC	
E	33 BSC	
E1	30.48 BSC	
E2	—	14.50
E3	3.43	—
E4	9.00	—

NOTES:
1. DIMENSIONS AND TOLERANCING PER ASME Y14.5M-1994.
2. DIMENSIONS IN MILLIMETERS.
3. MAXIMUM SOLDER BALL DIAMETER MEASURED PARALLEL TO DATUM A.
4. DIMENSIONS DEFINE THE AREA OCCUPIED BY THE DIE AND UNDERFILL. ACTUAL SIZE OF THIS AREA MAY BE SMALLER THAN SHOWN.

Figure 25. MPC107 Package Dimensions and Pinout Assignments

1.5.3 Pinout Listings

Table 17 provides the pinout listing for the MPC107, 503 FC-PBGA package.

Table 17. MPC107 Pinout Listing

Name	Pin Number	Type	Supply Voltage	Output Driver Type	Notes
60x Processor Interface Signals					
A[0:31]	AE22, AE16, AA14, AE17, AD21, AD14, AD20, AB16, AB20, AB15, AA20, AD13, Y15, AE12, AD15, AB9, AB14, AA8, AC13, Y12, Y11, AE15, AE13, AA16, Y13, AB8, AD12, AE10, AB13, Y9, Y8, AD9	I/O	BV_{DD}	DRV_CPU	4
$\overline{\text{AACK}}$	AC7	Output	BV_{DD}	DRV_CPU	
$\overline{\text{ARTRY}}$	Y7	I/O	BV_{DD}	DRV_CPU	15
$\overline{\text{BG0}}$	AE11	Output	BV_{DD}	DRV_CPU	
$\overline{\text{BG1}}$	AD11	Output	BV_{DD}	DRV_CPU	
$\overline{\text{BR0}}$	AB17	Input	BV_{DD}	—	
$\overline{\text{BR1}}$	Y14	Input	BV_{DD}	—	10
$\overline{\text{CI}}$	AD16	I/O	BV_{DD}	DRV_CPU	
$\overline{\text{DBG0}}$	AC10	Output	BV_{DD}	DRV_CPU	
$\overline{\text{DBG1}}$	AD10	Output	BV_{DD}	DRV_CPU	
$\overline{\text{DBGLB}}$	AB10	Output	BV_{DD}	DRV_CPU	
DH[0:31]	P1, R1, P2, T4, T1, T3, R4, P6, U6, V5, V2, T5, U1, R6, W1, V4, W2, U4, T2, V6, W3, W5, Y1, Y2, Y4, Y5, AA1, AA2, AA4, AB1, AB3, AB4	I/O	BV_{DD}	DRV_CPU	4
DL[0:31]	AA7, W6, AB6, AA6, AB5, AC4, AD3, AB7, AE1, W4, N6, M1, N3, N4, N5, N1, M2, R2, V1, P5, P4, N2, U2, AE4, AE6, AE2, AE3, AE7, AD5, AB2, AC2, AC1	I/O	BV_{DD}	DRV_CPU	4
DP[0:7]	AE9, AD6, AD8, AD1, AE8, AD7, AD4, AE5	I/O	BV_{DD}	DRV_CPU	4
$\overline{\text{GBL}}$	AD17	I/O	BV_{DD}	DRV_CPU	
$\overline{\text{LBCLAIM}}$	Y17	Input	BV_{DD}	—	
$\overline{\text{TA}}$	AE14	I/O	BV_{DD}	DRV_CPU	15
$\overline{\text{TBST}}$	AE21	I/O	BV_{DD}	DRV_CPU	

Table 17. MPC107 Pinout Listing (continued)

Name	Pin Number	Type	Supply Voltage	Output Driver Type	Notes
$\overline{\text{TEA}}$	AB11	Output	BV_{DD}	DRV_CPU	
$\overline{\text{TS}}$	AA10	I/O	BV_{DD}	DRV_CPU	15
TSIZ[0:2]	AE19,AD18,AB18	I/O	BV_{DD}	DRV_CPU	4
TT[0:4]	AD19,AC19,AB19,AA19,AA18	I/O	BV_{DD}	DRV_CPU	4
$\overline{\text{WT}}$	AC16	I/O	BV_{DD}	DRV_CPU	
PCI Interface Signals					
AD[31:0]	N23, N21, M20, M21, M22, M24, M25, L20, L22, K25, K24, K23, K21, J20, J24, J25, H20, F24, E25, F21, E24, E22, D25, A25, B25, A23, B23, B22, C22, C25, D23, D21	I/O	OV_{DD}	DRV_PCI	4, 11
$\overline{\text{C/BE}}$[3:0]	L24, J22, G22, A24,	I/O	OV_{DD}	DRV_PCI	4, 11
$\overline{\text{DEVSEL}}$	G23	I/O	OV_{DD}	DRV_PCI	6, 11
$\overline{\text{FRAME}}$	G20	I/O	OV_{DD}	DRV_PCI	6, 11
$\overline{\text{GNT}}$[4:0]	T24, P22, P21, R22, N20	Output	OV_{DD}	DRV_PCI	4, 11
IDSEL	L25	Input	OV_{DD}	—	
$\overline{\text{INTA}}$	V21	Output	OV_{DD}	DRV_PCI	6, 11, 12
$\overline{\text{IRDY}}$	H24	I/O	OV_{DD}	DRV_PCI	6, 11
$\overline{\text{LOCK}}$	G21	Input	OV_{DD}	—	6
PAR	G24	I/O	OV_{DD}	DRV_PCI	11
$\overline{\text{PERR}}$	G25	I/O	OV_{DD}	DRV_PCI	6, 11, 13
$\overline{\text{REQ}}$[4:0]	W25, V25, U25, T25, T23	Input	OV_{DD}	—	10
$\overline{\text{SERR}}$	F25	I/O	OV_{DD}	DRV_PCI	6, 11, 12
$\overline{\text{STOP}}$	H21	I/O	OV_{DD}	DRV_PCI	6, 11
$\overline{\text{TRDY}}$	H25	I/O	OV_{DD}	DRV_PCI	6, 11
Memory Interface Signals					
$\overline{\text{AS}}$	A4	Output	GV_{dd}	DRV_MEM_CTRL	
$\overline{\text{CAS}}$/DQM[0:7]	A2, B1, A11, A10, B3, C2, F12, D11	Output	GV_{dd}	DRV_MEM_CTRL	4
CKE	A12	Output	GV_{dd}	DRV_MEM_CTRL	1
$\overline{\text{FOE}}$	A13	I/O	GV_{dd}	DRV_MEM_CTRL	1, 2

Table 17. MPC107 Pinout Listing (continued)

Name	Pin Number	Type	Supply Voltage	Output Driver Type	Notes
MDH[0:31]	M6, L4, L6, K2, K4, K5, J4, J6, H4, H5, G3, G5, G6, F5, F1, E1, B14, D15, B15, E16, D16, C16, D18, D17, B17, F18, E19, E20, B19, B20, B21, A22	I/O	GV_{DD}	DRV_MEM_DATA	4
MDL[0:31]	M5, L1, L2, K1, K3, J1, J2, H1, H2, H6, G2, G4, F4, G1, F2, E2, F14, F15, A16, F17, B16, A17, A18, A19, B18, E18, D19, F19, A20, C19, D20, A21	I/O	GV_{DD}	DRV_MEM_DATA	3, 4
PAR/AR[0:7]	D2, C1, A15, A14, D1, D3, F13, C13	I/O	GV_{DD}	DRV_MEM_DATA	4
$\overline{RAS}/\overline{CS}$[0:7]	E6, C4, D5, E4, C10, F11, B10, B11	Output	GV_{DD}	DRV_MEM_ADDR	4
$\overline{RCS0}$	D10	I/O	GV_{DD}	DRV_MEM_ADDR	1, 2
$\overline{RCS1}$	B9	Output	GV_{DD}	DRV_MEM_DATA	
$\overline{RCS2}$	B5	Output	GV_{DD}	DRV_MEM_ADDR	
$\overline{RCS3}$	D7	Output	GV_{DD}	DRV_MEM_ADDR	
SDBA0	A9	Output	GV_{DD}	DRV_MEM_ADDR	1, 2
SDBA1	A8	Output	GV_{DD}	DRV_MEM_ADDR	
$\overline{SDCAS}$	D4	Output	GV_{DD}	DRV_MEM_ADDR	1
SDMA [13:0]	E10, F9, D9, F8, E8, D8, B8, E7, C7, B7, A7, B6, A6, A5	Output	GV_{DD}	DRV_MEM_ADDR	4, 5
$\overline{SDRAS}$	B4	Output	GV_{DD}	DRV_MEM_ADDR	1
$\overline{WE}$	A3	Output	GV_{DD}	DRV_MEM_ADDR	
PIC Control Signals					
$\overline{INT}$	Y22	Output	OV_{DD}	DRV_CPU	16
IRQ_0/S_INT	U24	Input	OV_{DD}	—	
IRQ_1/S_CLK	C24	I/O	OV_{DD}	DRV_PCI	
IRQ_2/S_RST	T21	I/O	OV_{DD}	DRV_PCI	
IRQ_3/S_FRAME	U20	I/O	OV_{DD}	DRV_PCI	
IRQ_4/L_INT	V22	I/O	OV_{DD}	DRV_PCI	

Table 17. MPC107 Pinout Listing (continued)

Name	Pin Number	Type	Supply Voltage	Output Driver Type	Notes
I^2C Control Signals					
SCL	AB25	I/O	OV_{DD}	DRV_CPU	8, 12
SDA	AB24	I/O	OV_{DD}	DRV_CPU	8, 12
Clock Signals					
CKO	V20	Output	OV_{DD}	DRV_PCI	
CPU_CLK[0:2]	AA12, AA13, AB12	Output	BV_{DD}	DRV_CPU_CLK	4
OSC_IN	U22	Input	OV_{DD}	—	
PCI_CLK [0:4]	R25, P24, R24, N24, N25	Output	OV_{DD}	DRV_MEM_CTRL	4
PCI_SYNC_IN	P20	Input	OV_{DD}	—	
PCI_SYNC_OUT	P25	Output	OV_{DD}	DRV_MEM_CTRL	
SDRAM_CLK [0:3]	D14, D13, E12, E14	Output	GV_{DD}	DRV_MEM_CTRL	4
SDRAM_SYNC_IN	E13	Input	GV_{DD}	—	
SDRAM_SYNC_OUT	D12	Output	GV_{DD}	DRV_MEM_CTRL	
Miscellaneous Signals					
$\overline{\text{HRESET}}$	AA23	Input	OV_{DD}	—	
$\overline{\text{HRESET\_CPU}}$	AB21	Output	BV_{DD}	DRV_CPU	10, 12
$\overline{\text{MCP}}$	AE20	Output	OV_{DD}	DRV_CPU	12, 16
NMI	AC25	Input	OV_{DD}	—	
$\overline{\text{QACK}}$	AE18	Output	BV_{DD}	DRV_CPU	10
$\overline{\text{QREQ}}$	M4	Input	BV_{DD}	—	
$\overline{\text{SRESET}}$	Y18	Output	BV_{DD}	DRV_CPU	10
Test/Configuration Signals					
PLL_CFG[0:3]	AC22, AD23, AD22, AE23	Input	OV_{DD}	—	2,4
TCK	W24	Input	OV_{DD}	—	7, 10
TDI	Y25	Input	OV_{DD}	—	7, 10
TDO	W23	Output	OV_{DD}	DRV_PCI	
$\overline{\text{TEST}}$	AA25	Input	OV_{DD}	—	7, 10
$\overline{\text{TEST1}}$	V24	Input	OV_{DD}	—	8
$\overline{\text{TEST2}}$	D6	Input	GV_{DD}	—	9
TMS	Y24	Input	OV_{DD}	—	7,10
TRIG_IN	W22	Input	OV_{DD}	—	
TRIG_OUT	W21	Output	OV_{DD}	DRV_CPU	10

Table 17. MPC107 Pinout Listing (continued)

Name	Pin Number	Type	Supply Voltage	Output Driver Type	Notes
$\overline{TRST}$	AA24	Input	OV_{DD}	—	7, 10, 14
Power and Ground Signals					
AV_{DD}	AE24	Input	—	—	—
GND	AA21, AB22, AC11, AC14, AC17, AC20, AC23, AC3, AC5, AC8, AD24, AE25, C12, C15, C18, C21, C23, C3, C6, C9, E3, F10, F16, F20, F23, F6, G11, G13, G15, G18, G8, H19, H3, H7, J23, K20, K6, L19, L3, L7, M23, N19, N7, P3, R19, R23, R7, T20, T6, U3, V19, V23, V7, W11, W13, W15, W18, W8, Y10, Y16, Y19, Y20, Y3, Y6	Input	—	—	
GV_{DD}	B2, C5, C8, C11, C14, C17, C20, E5, E9, E11, E15, E17, F3, G7, G9, G12, G14, G17, G19, J3, J5, J7, L5, M3, M7	Input	—	—	
LAV_{DD}	F7	Input	—	—	
LV_{DD}	D22, F22, H22, K22, N22, T22	Input	—	—	
OV_{DD}	B24, E21, E23, H23, J19, J21, L21, L23, M19, P19, P23, R21, U19, U21, U23, Y23	Input	—	—	
BV_{DD}	P7, R3, R5, U5, U7, V3, W7, W9, W12, W14, W17, AA3, AA5, AA9, AA11, AA15, AA17, AC6, AC9, AC12, AC15, AC18, AC21, AD2	Input	—	—	
V_{DD}	K19, W16, T19, G10, G16, K7, T7, W10, W19, W20, Y21, AA22, AB23, AC24, AD25	Input	—	—	

Table 17. MPC107 Pinout Listing (continued)

Name	Pin Number	Type	Supply Voltage	Output Driver Type	Notes
Manufacturing Pins					
FTP[2:3]	R20, D24	I/O	OV_{DD}	DRV_PCI	4, 8
MTP[1:2]	B12, B13	I/O	GV_{DD}	DRV_MEM_CTRL	4, 9

Notes:
1. This pin has an internal pull-up resistor which is enabled only when the MPC107 is in reset state. The value of the internal pull-up resistor is not guaranteed, but is sufficient to ensure that a logic 1 is read into configuration bits during reset.
2. This pin is a reset configuration pin.
3. MDL[0] is a reset configuration pin and has an internal pull-up resistor which is enabled only when the MPC107 is in the reset state.The value of the internal pull-up resistor is not guaranteed, but is sufficient to ensure that a logic 1 is read into configuration bits during reset.
4. Multi-pin signals such as AD[0:31] or DL[0:31] have their physical package pin numbers listed in order corresponding to the signal names. Ex: AD0 is on pin D21, AD1 is on pin D23, ..., AD31 is on pin N23.
5. SDMA[10:1] are reset configuration pins and have internal pull-up resistors which are enabled only when the MPC107 is in the reset state.The values of the internal pull-up resistors is not guaranteed, but are sufficient to ensure that logic 1s are read into the configuration bits during reset.
6. Recommend a weak pull-up resistor (2–10 kΩ) be placed on this PCI control pin to LV_{DD}.
7. V_{IH} and V_{IL} for these signals are the same as the PCI V_{IH} and V_{IL} entries in Table 3.
8. Recommend a weak pull-up resistor (2–10 kΩ) be placed on this pin to OV_{DD}.
9. Recommend a weak pull-up resistor (2–10 kΩ) be placed on this pin to GV_{DD}.
10. This pin has an internal pull-up resistor; the value of the internal pull-up resistor is not guaranteed, but is sufficient to prevent unused inputs from floating.
11. This pin is affected by programmable PCI_HOLD_DEL parameter, see Section 1.4.2.4, “PCI Signal Output Hold Timing.”
12. This pin is an open drain signal.
13. This pin is a sustained three-state pin as defined by the *PCI Local Bus Specification.*
14. See Section 1.7.3, “Connection Recommendations,” for additional information on this pin.
15. Recommend a weak pull-up resistor (2–10 kΩ) be placed on this pin to BV_{DD}.
16. If BV_{DD} = 2.5 V ± 5%, this microprocessor interface pin needs to be DC voltage level shifted from OV_{DD} (3.3 V ± 0.3 V) to 2.5 V ± 5%; this can typically be accomplished with a two resistor voltage divider circuit since the signal is an output only signal.

1.6 PLL Configuration

The MPC107 internal PLL is configured by the PLL_CFG[0:3] signals. For a given PCI_SYNC_IN (PCI bus) frequency, the PLL configuration signals set the core/memory/processor PLL (VCO) frequency of operation for the PCI-to-core/memory/processor frequency multiplying, if any. All valid PLL configurations for the MPC107 are shown in Table 18. Range values are shown rounded down to the nearest whole number (decimal place accuracy removed) for clarity.

Table 18. MPC107 Bridge Controller PLL Configuration

Ref	PLL_CFG[0:3] [2]	66 MHz Part		100 MHz Part		PCI:Core Ratio	VCO Multiplier
		PCI_SYNC_IN Range (MHz)	Core/Mem/CPU Range (MHz)	PCI_SYNC_IN Range (MHz)	Core/Mem/CPU Range (MHz)		
1	0001	25 [4]–33 [5]	25–33	25 [4]–50 [5]	25–50	1	4
2	0010	13 [4]–16 [5]	26–34	13 [4]–25 [5]	26–50	2	4
3	0011	Bypass		Bypass		Bypass	Bypass
5	0101	25 [4]–33 [7]	50–66	25 [4]–50 [7]	50–100	2	2
8	1000	17 [4]–22 [7]	51–66	17 [4]–33 [7]	50–100	3	2
9	1001	34 [4]–44 [7]	51–66	33 [4]–66 [6]	50–100	1.5	2
A	1010	13 [4]–16 [7]	52–64	13 [4]–25 [7]	52–100	4	2
C	1100	20 [4]–26 [7]	50–65	20 [4]–40 [7]	50–100	2.5	2
D	1101	50 [4]–66 [6]	50–66	50 [4]–66 [6]	50–66	1	2
F	1111	Clock off [3]	Not usable	Clock off [3]	Not usable	Off	Off

Notes:
1. PLL_CFG[0:3] settings not listed (0000, 0100, 0110, 0111, 1011, and 1110) are reserved.
2. In PLL bypass mode, the PCI_SYNC_IN input signal clocks the internal core directly, the PLL is disabled, and the PCI:core mode is set for 1:1 mode operation. The AC timing specifications given in this document do not apply in PLL bypass mode.
3. In clock off mode, no clocking occurs inside the MPC107 regardless of the PCI_SYNC_IN input.
4. Limited due to minimum memory VCO (100 MHz).
5. Limited due to maximum memory VCO = (2x maximum memory bus speed).
6. Limited by maximum PCI bus speed (66 MHz).
7. Limited by maximum memory bus speed.

1.7 System Design Information

This section provides electrical and thermal design recommendations for successful application of the MPC107.

1.7.1 PLL Power Supply Filtering

The AV_{DD} and LAV_{DD} power signals are provided on the MPC107 to provide power to the peripheral logic/memory bus PLL and the SDRAM clock delay-locked loop (DLL), respectively. To ensure stability of the internal clocks, the power supplied to the AV_{DD} and LAV_{DD} input signals should be filtered of any

noise in the 500-kHz to 10-MHz resonant frequency range of the PLLs. A separate circuit similar to the one shown in Figure 26 using surface mount capacitors with minimum effective series inductance (ESL) is recommended for each of the AV_{DD} and LAV_{DD} power signal pins. 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 using multiple values.

The circuits should be placed as close as possible to the respective input signal pins to minimize noise coupled from nearby circuits. Routing directly as possible from the capacitors to the input signal pins with minimal inductance of vias is important but proportionately less critical for the LAV_{DD} pin.

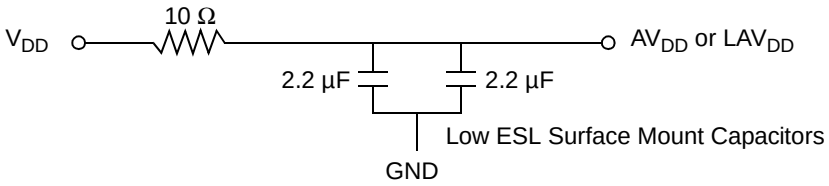


Figure 26. PLL Power Supply Filter Circuit

1.7.2 Decoupling Recommendations

Due to the MPC107 dynamic power management feature, large address and data buses, and high operating frequencies, the MPC107 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 MPC107 system, and the MPC107 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}, GV_{DD}, and LV_{DD} pin of the MPC107. It is also recommended that these decoupling capacitors receive their power from separate V_{DD}, OV_{DD}, GV_{DD}, and GND power planes in the PCB, utilizing short traces to minimize inductance. These capacitors should have a value of 0.1 µF. Only ceramic SMT (surface mount technology) capacitors should be used to minimize lead inductance, preferably 0508 or 0603, oriented such that connections are made along the length of the part.

In addition, it is recommended that there be several bulk storage capacitors distributed around the PCB, feeding the V_{DD}, OV_{DD}, GV_{DD}, BV_{DD}, and LV_{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: 100–330 µF (AVX TPS tantalum or Sanyo OSCON).

1.7.3 Connection Recommendations

To ensure reliable operation, it is highly recommended to connect unused inputs to an appropriate signal level. Unused active low inputs should be tied to OV_{DD}. Unused active high inputs should be connected to GND. All NC (no-connect) signals must remain unconnected.

Power and ground connections must be made to all external V_{DD}, OV_{DD}, GV_{DD}, LV_{DD}, BV_{DD}, and GND pins of the MPC107.

The PCI_SYNC_OUT signal is intended to be routed halfway out to the PCI devices and then returned to the PCI_SYNC_IN input of the MPC107.

The SDRAM_SYNC_OUT signal is intended to be routed halfway out to the SDRAM devices and then returned to the SDRAM_SYNC_IN input of the MPC107. The trace length may be used to skew or adjust

the timing window as needed. Refer to Motorola Application Note AN1849/D, *MPC107 Design Guide*, for more information on this topic.

The $\overline{\text{TRST}}$ signal must be asserted during reset to ensure proper initialization and operation of the MPC107. It is recommended that the $\overline{\text{TRST}}$ signal be connected to the system $\overline{\text{HRESET}}$ signal or pulled down with a 100-Ω to 1-kΩ resistor.

1.7.4 Pull-Up/Pull-Down Resistor Requirements

The data bus input receivers are normally turned off when no read operation is in progress; therefore, they do not require pull-up resistors on the bus. The processor data bus signals are: DH[0:31], DL[0:31], and DP[0:7]. The memory data bus signals are: MDH[0:31], MDL[0:31], and PAR/AR[0:7].

If the 32-bit data bus mode is selected, the input receivers of the unused data and parity bits (DL[0:31], DP[4:7], MDL[0:31], and PAR[4:7]) will be disabled, and their outputs will drive logic zeros when they would otherwise normally be driven. For this mode, these pins do not require pull-up resistors, and should be left unconnected by the system to minimize possible output switching.

It is recommended that $\overline{\text{ARTRY}}$, $\overline{\text{TA}}$, and $\overline{\text{TS}}$ have weak pull-up resistors (2–10 kΩ) connected to BV_{DD}.

It is recommended that MTP[1:2] and $\overline{\text{TEST2}}$ have weak pull-up resistors (2–10 kΩ) connected to GV_{DD}.

It is recommended that the following signals be pulled up to OV_{DD} with weak pull-up resistors (2–10 kΩ): SDA, SCL, $\overline{\text{TEST1}}$, and FTP[2:3].

It is recommended that the following PCI control signals be pulled up to LV_{DD} with weak pull-up resistors (2–10 kΩ): $\overline{\text{DEVSEL}}$, $\overline{\text{FRAME}}$, $\overline{\text{IRDY}}$, $\overline{\text{LOCK}}$, $\overline{\text{PERR}}$, $\overline{\text{SERR}}$, $\overline{\text{STOP}}$, $\overline{\text{TRDY}}$, and $\overline{\text{INTA}}$. The resistor values may need to be adjusted stronger to reduce induced noise on specific board designs.

The following pins have internal pull-up resistors enabled at all times: $\overline{\text{REQ}}$[0:4], TCK, TDI, TMS, $\overline{\text{TRST}}$, $\overline{\text{BR1}}$, $\overline{\text{HRESET\_CPU}}$, $\overline{\text{QACK}}$, $\overline{\text{SRESET}}$, $\overline{\text{TEST}}$, and $\overline{\text{TRIG\_OUT}}$. See Table 17 for more information.

The following pins have internal pull-up resistors enabled only while device is in the reset state: MDL0, $\overline{\text{FOE}}$, $\overline{\text{RCS0}}$, $\overline{\text{SDRAS}}$, $\overline{\text{SDCAS}}$, CKE, SDBAO, and SDMA[10:1]. See Table 17 for more information.

The following pins are reset configuration pins: MDL0, $\overline{\text{FOE}}$, $\overline{\text{RCS0}}$, SDBAO, SDMA[10:1], and PLL_CFG[0:3]. These pins are sampled during reset to configure the device.

Any other unused active-low input pins should be tied to a logic one level via weak pull-up resistors (2–10 kΩ) to the appropriate power supply listed in Figure 17. Unused active-high input pins should be tied to GND via weak pull-down resistors (2–10 kΩ).

1.7.5 Thermal Management Information

An estimation of the chip junction temperature, T_J, can be obtained from the equation:

$$T_J = T_A + (R_{\theta JA} \times P_D)$$

where

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. Table 6 has four junction-to-ambient thermal resistances ($R_{\theta JA}$ or $R_{\theta JMA}$). Two test boards are used: single-signal-layer (1s) and four-layer boards with two internal planes

(2s2p). Which value is closer to the application depends on the system board thermal resistance and the density of other high-power dissipation components.

To illustrate the process, determine the junction temperature based on the values provided in Table 6 for an MPC107 that is mounted on a board with many internal planes using arbitrary values. If the MPC107 is doing most of the power dissipation, use $R_{\theta JMA}$ of 26°C/W given in Table 6. The ambient temperature near the device is 45°C. Suppose the total typical power dissipation at 100 MHz core frequency is 2.1 W (see Table 5). The junction temperature is:

$$T_J = 45 + (2.1 \times 26) = 100°C.$$

If this value is less than the maximum junction temperature noted in Table 1, the MPC107 will not need a heat sink. If the ambient temperature is higher or the power dissipation is higher because of faster bus speed, the device will probably need a heat sink.

The MPC107 may need a heat sink depending on the system. This section provides thermal management information for the flip chip plastic ball grid array (FC-PBGA) package for air-cooled applications. Proper thermal control design is primarily dependent on the system-level design—the heat sink, airflow, and thermal interface material. To reduce the die-junction temperature, heat sinks may be attached to the package by several methods—spring clip to holes in the printed-circuit board or package, and mounting clip and screw assembly (see Figure 27); however, due to the potential large mass of the heat sink, attachment through the printed-circuit board is suggested. The force of the heat sink on the die should not exceed 6 lb. The heat sink surface must be flat without protrusions and must be parallel with the die as the heat sink is brought into contact to avoid chipping the edges of the die and the heat sink. Because of the small contact area of the heat sink, it is suggested that the mounting force be centered over the die.

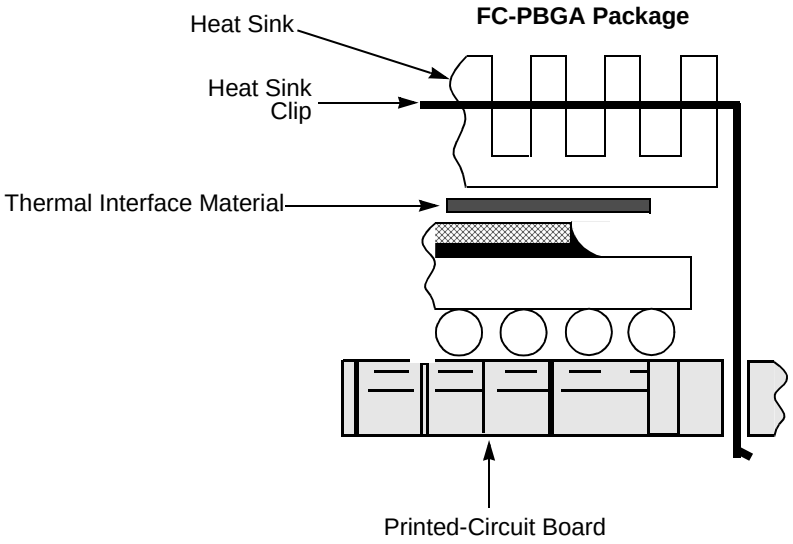


Figure 27. Package Exploded Cross-Sectional View with Several Heat Sink Options

The board designer can choose between several types of heat sinks to place on the MPC107. There are several commercially available heat sinks for the MPC107 provided by the following vendors:

Aavid Thermalloy 603-224-9988
80 Commercial St.
Concord, NH 03301
Internet: www.aavidthermalloy.com

Alpha Novatech 473 Sapena Ct. #15 Santa Clara, CA 95054 Internet: www.alphanovatech.com	408-749-7601
International Electronic Research Corporation (IERC) 413 North Moss St. Burbank, CA 91502 Internet: www.ctscorp.com	818-842-7277
Tyco Electronics Chip Coolers™ P.O. Box 3668 Harrisburg, PA 17105-3668 Internet: www.chipcoolers.com	800-522-6752
Wakefield Engineering 33 Bridge St. Pelham, NH 03076 Internet: www.wakefield.com	603-635-5102

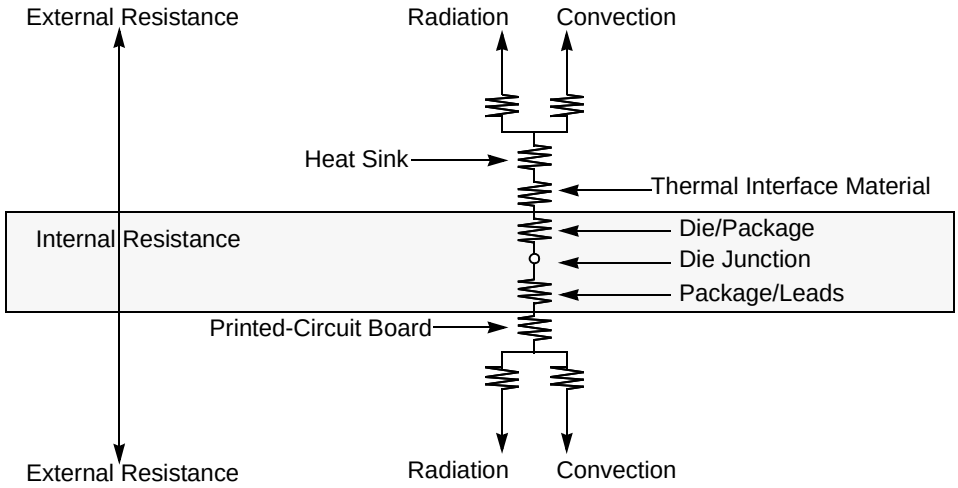
Ultimately, the final selection of an appropriate heat sink depends on many factors, such as thermal performance at a given air velocity, spatial volume, mass, attachment method, assembly, and cost.

1.7.6 Internal Package Conduction Resistance

For the exposed-die packaging technology, shown in Figure 3, the intrinsic conduction thermal resistance paths are as follows:

- The die junction-to-case (actually top-of-die, since silicon die is exposed) thermal resistance
- The die junction-to-ball thermal resistance

Figure 28 depicts the primary heat transfer path for a package with an attached heat sink mounted to a printed-circuit board.



(Note the internal versus external package resistance.)

Figure 28. FC-PBGA Package with Heat Sink Mounted to a Printed-Circuit Board

Heat generated on the active side of the chip is conducted through the silicon, then through the heat sink attach material (or thermal interface material), and finally to the heat sink, where it is removed by forced-air convection.

Because the silicon thermal resistance is quite small for a first-order analysis, the temperature drop in the silicon may be neglected. Thus, the thermal interface material and the heat sink conduction/convective thermal resistances are the dominant terms.

1.7.6.1 Thermal Interface Materials

A thermal interface material is recommended at the package lid-to-heat sink interface to minimize the thermal contact resistance. For those applications where the heat sink is attached by spring clip mechanism, Figure 29 shows the thermal performance of three thin-sheet thermal-interface materials (silicone, graphite/oil, floroether oil), a bare joint, and a joint with thermal grease as a function of contact pressure. As shown, the performance of these thermal interface materials improves with increasing contact pressure. The use of thermal grease significantly reduces the interface thermal resistance. That is, the bare joint results in a thermal resistance approximately seven times greater than the thermal grease joint.

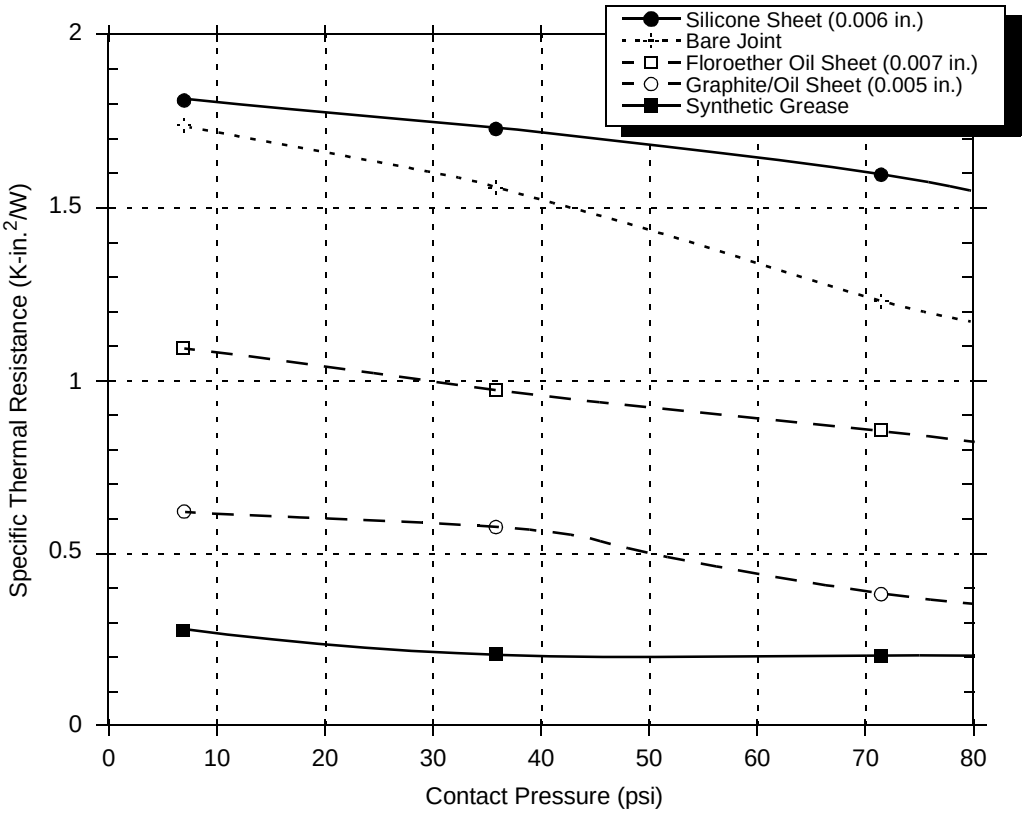


Figure 29. Thermal Performance of Select Thermal Interface Material

Often, heat sinks are attached to the package by means of a spring clip to holes in the printed-circuit board (see Figure 28). Therefore, the synthetic grease offers the best thermal performance, considering the low interface pressure and is recommended. Of course, the selection of any thermal interface material depends on many factors—thermal performance requirements, manufacturability, service temperature, dielectric properties, cost, etc.

The board designer can choose between several types of thermal interface. Heat sink adhesive materials should be selected based upon high conductivity, yet adequate mechanical strength to meet equipment shock/vibration requirements. There are several commercially available thermal interfaces and adhesive materials provided by the following vendors:

Chomerics, Inc. 77 Dragon Ct. Woburn, MA 01888-4014 Internet: www.chomerics.com	781-935-4850
Dow-Corning Corporation Dow-Corning Electronic Materials 2200 W. Salzburg Rd. Midland, MI 48686-0997 Internet: www.dow.com	800-248-2481
Shin-Etsu MicroSi, Inc. 10028 S. 51st St. Phoenix, AZ 85044 Internet: www.microsi.com	888-642-7674
The Bergquist Company 18930 West 78th St. Chanhassen, MN 55317 Internet: www.bergquistcompany.com	800-347-4572
Thermagon Inc. 4707 Detroit Ave. Cleveland, OH 44102 Internet: www.thermagon.com	888-246-9050

The following section provides a heat sink selection example using one of the commercially available heat sinks.

1.7.6.2 Thermal Interface Materials

For preliminary heat sink sizing, the die-junction temperature can be expressed as follows:

$$T_j = T_i + T_r + (\theta_{jc} + \theta_{int} + \theta_{sa}) \times P_d$$

where:

T_j = die-junction temperature

T_i = inlet cabinet ambient temperature

T_r = air temperature rise within the computer cabinet

θ_{jc} = junction-to-case thermal resistance

θ_{int} = adhesive or interface material thermal resistance

θ_{sa} = heat sink base-to-ambient thermal resistance

P_d = power dissipated by the device

During operation, the die-junction temperatures (T_j) should be maintained less than the value specified in Table 1. The temperature of air cooling the component greatly depends on the ambient inlet air temperature and the air temperature rise within the electronic cabinet. An electronic cabinet inlet-air temperature (T_i) may range from 30° to 40°C. The air temperature rise within a cabinet (T_r) may be in the range of 5° to

10°C. The thermal resistance of the thermal interface material (θ_{int}) is typically about 1.5°C/W. For example, assuming a T_a of 60°C, a T_r of 5°C, a FC-PBGA package θ_{jc} = 0.1, and a typical power consumption (P_d) of 2.1 W, the following expression for T_j is obtained:

Die-junction temperature: $T_j = 60°C + 5°C + (0.1°C/W + 1.5°C/W + \theta_{sa}) \times 2.1\ W$

For this example, a θ_{sa} value of 17.4°C/W or less is required to maintain the die junction temperature below the maximum value of Table 1. Though the die junction-to-ambient and the heat sink-to-ambient thermal resistances are a common figure-of-merit used for comparing the thermal performance of various microelectronic packaging technologies, one should exercise caution when only using this metric in determining thermal management because no single parameter can adequately describe three-dimensional heat flow. The final die-junction operating temperature is not only a function of the component-level thermal resistance, but the system-level design and its operating conditions. In addition to the component's power consumption, a number of factors affect the final operating die-junction temperature—airflow, board population (local heat flux of adjacent components), heat sink efficiency, heat sink attach, heat sink placement, next-level interconnect technology, system air temperature rise, altitude, etc.

1.7.7 References

Semiconductor Equipment and Materials International
805 East Middlefield Rd.
Mountain View, CA 94043
(415) 964-5111

MIL-SPEC and EIA/JESD (JEDEC) specifications are available from Global Engineering Documents at 800-854-7179 or 303-397-7956.

JEDEC specifications are available on the WEB at http://www.jedec.org.

1.8 Document Revision History

Table 19 provides a revision history for this hardware specification.

Table 19. Document Revision History

Rev. No.	Substantive Changes
0.0	Preliminary release with some TBDs in the spec tables
0.1	Removed references to CBGA packaging. Removed references to BVdd = 2.5 V and GVdd = 2.5 V until device characterization is complete. Corrected Power Supply Ramp Up range in Figure 2 to show Vdd being stable before 100 microsecond PLL Relock time. Modified Table 4: • Filled in current values from IBIS model. • Changed DRV_STD to DRV_CPU and changed OVdd to BVdd. Added Note 10, referencing power consumption on PLL supply voltage pins to Table 5. Updated Table 6 PBGA package thermal characteristics. Corrected DLL Lock Range (DLL_EXTEND=1) equation in Table 8. Modified Figure 6 reducing T_{loop} Propagation Delay Time from 40 ns to 15 ns. Modified Figure 22 for PBGA packaging. Updated Table 17, its notes, and corresponding text in Section 1.7.4. Modified Note 5 of Table 18, reducing maximum memory VCO frequency from 225 to 200 MHz. Updated the affected PLL_CFG[0-3] entries (0001 and 0010) in the table. Revised Section 1.7.5, for PBGA packaging.

Table 19. Document Revision History (continued)

Rev. No.	Substantive Changes
0.2	Lowered PCI Input Frequency (PCI_SYNC_IN) in Table 7 from 25 to 12.5 MHz, see Table 18 for specific details on applicability of lower input frequency. Modified Table 8: • Completed specification numbering. • Combined PCI_SYNC_IN jitter specifications 7 and 8, into specification 7. • Added specification 9d. • Updated values for specifications 7, 9b, and 9c. • Deleted OSC_IN Jitter (Cycle-to-Cycle) specification. • Added Note 8 to specifications 1a, 1b, 17, and 18; updated the Min part of these specifications to correspond to the lower PCI 12.5 MHz input frequency. Added Figure 5. Replaced Input AC Timing TBDs in Table 9 with values. Replaced Output AC Timing TBDs for specifications 12c, 12d, 12e, and 14a in Table 10 with values. Replaced Figure 22 with Motorola standard packaging drawing for 503-pin PBGA. Updated Table 18: • Lowered input frequency on Refs 2 and C. • Ref A is changed to reserved. • Ref 8 is changed to usable for 66 MHz devices.
0.3	Removed references to the suspend (power-saving) mode. In Section 1.3, technology reference updated from 0.35 µm to 0.29 µm CMOS. Updated Figure 2 and Note 5 to indicate only $\overline{\text{HRESET}}$ must transition to a logic 1 in one clock cycle for the device to be in the non-reset state. Modified Table 3: • Changed minimum Input High Voltage, for PCI only from 0.5*OVdd to 0.65*OVdd and added Note 6. • Changed condition on Input Low Voltage, V_{IL}, from All inputs except OSC_IN to All inputs except PCI_SYNC_IN. • Replaced minimum CV_{IH} formula, 0.5*OVdd, with 2.4 V value. • Replaced maximum CV_{IL} formula, 0.3*OVdd, with 0.4 V value. Updated IBIS model version from v1.0 to v1.1, changed LVdd references to OVdd in Table 4 and notes, changed Notes 3 and 4 for the values to be read from the IBIS model's I(Min) column, and updated the I_{OL} column values. Replaced most TBDs in Table 5 for with new preliminary power consumption estimates. Deleted specs 22 and 23 from Table 8; they were DC levels covered in Table 3. Replaced TBDs in Table 10 for spec 14b. Separated CKE output valid timing from spec 12b (added 12b1 and 12b2) dependent on device's maximum operating frequency; see Table 10. Replaced TBDs in Table 15 for specs 3, 5, and 6. Modified Table 17: • Renamed SUSPEND pin (V24) to $\overline{\text{TEST1}}$ and moved it from the Miscellaneous Signals group to the Test/Configuration Signals group. Added notes about pulling it up to OVdd. • Renamed RTC pin (D6) to $\overline{\text{TEST2}}$ and moved it from the Memory Interface Signals group to the Test/Configuration Signals group. Added notes about pulling it up to GVdd. • Added Note 14 for $\overline{\text{TRST}}$ pin. • Added Note 6 for $\overline{\text{INTA}}$ pin. Also added $\overline{\text{INTA}}$ to LVdd pull-up list in Section 1.7.4. Deleted Note 1 from Table 18; adjusted remaining note numbers. Added paragraph in Section 1.7.3 for $\overline{\text{TRST}}$ connection.

Table 19. Document Revision History (continued)

Rev. No.	Substantive Changes
0.4	Added BVdd = 2.5 V information to document. Updated Table 4 and associated notes. Updated specific operating conditions at the top of the following tables: Table 7 through Table 10, Table 12, and Table 14 through Table 16. Replaced Figure 22, with a clearer diagram of the 503 PBGA package. Modified Table 17: • Added Note 15 for BVdd pull-ups to the following pins: $\overline{\text{ARTRY}}$, $\overline{\text{TA}}$, and $\overline{\text{TS}}$. • Added Note 16 for $\overline{\text{INT}}$ signal in BVdd = 2.5 V applications. • Changed $\overline{\text{AACK}}$ pin type from I/O to output. • Changed Output Driver Type from DRV_MEM_DATA to DRV_MEM_ADDR on the following pins: $\overline{\text{FOE}}$, $\overline{\text{RCS0}}$, $\overline{\text{RCS2}}$, and $\overline{\text{RCS3}}$. • Deleted RTC signal (D6) from Memory Interface Signals group, since it is now $\overline{\text{TEST2}}$ in the Test/Configuration Signals group. Added PLL_CFG[0-3] = 0000 to Note 1 of Table 18 for reserved settings. Added BVdd pull-up information to Section 1.7.4.
0.5	Separated V_{OH} and V_{OL} DC specs for CPUCLK[0–2] signals at BVdd = 2.5 V from the other output pins' DC levels. Updated Table 8 with correct DLL_extend default value. Reversed vector ordering for the PCI Interface Signals in Table 17: $\overline{\text{C/BE}}$[0–3] changed to $\overline{\text{C/BE}}$[3–0], AD[0–31] changed to AD[31–0], $\overline{\text{GNT}}$[0–3] changed to $\overline{\text{GNT}}$[3–0], and $\overline{\text{REQ}}$[0–3] changed to $\overline{\text{REQ}}$[3–0]. The package pin number orderings were also reversed, meaning that pin functionality did not change. For example, AD0 is still on signal D21, AD1 is still on signal D23, ..., AD31 is still on signal N23. This change makes the vectored PCI signals in this hardware specification consistent with the PCI local bus specification and the *MPC107 PCI Bridge/Memory Controller User's Manual* vector ordering.
0.6	Updated Table 5 to include the maximum numbers. Corrected solder attach and ball information in Section 1.5.1 to 62 Sn/36 Pb/2 Ag. Table 17: Changed the voltage supply information for the $\overline{\text{MCP}}$ signal from BVDD to OVDD. Changed the note for $\overline{\text{MCP}}$ signal to match the supply voltage information.
1	Added Cautions to Table 2, in place of voltage sequencing requirement. Removed voltage sequencing note from Figure 2. Updated Table 5 with most recent power characterization data. Updated Table 6 to include more thermal characteristics. Updated definitions of DLL_Extend in Table 8, items 15 and 16. Updated locations of DLL_Extend in Figure 6. Table 17: Changed the driver type for $\overline{\text{DBG0}}$, $\overline{\text{DBG1}}$, and $\overline{\text{DBGLB}}$ to DRV_CPU—these signals are 60x signals. Changed signal name CPUCLK[0-2} to CPU_CLK[0:2] to correct signal name CPU_CLK[0:2]. Updated driver strengths of signals to be consistent with the user's manual. Removed Section 1.7.2. In Section 1.7.4, removed $\overline{\text{MCP}}$ from the list of pins requiring pull-up resistors. In Sections 1.7.5 and 1.7.6, added information on thermal management and internal package conduction resistance. Changed format of Section 1.9. In Section 1.9.2, added information about available part number specifications.
2	Table 2, updated cautions. Figure 2, updated notes. Section 1.4.1.5, replaced last sentence in first paragraph. Table 7, added notes. Figure 22, updated case drawing. Section 1.7.5 through Section 1.7.6.2, replaced these sections with updated information.

Table 19. Document Revision History (continued)

Rev. No.	Substantive Changes
3	Changed definition of DLL_EXTEND to DLL_STANDARD. Inserted new Figures 4 and 5 (overshoot/undershoot for PCI). Updated Figure 8 (old Figure 6) and added Figure 9 (new charts for DLL locking ranges).
4	Table 8, updated parameters for DLL locking rows (15 and 16) and note 6.

1.9 Ordering Information

Ordering information for the parts fully covered by this specification document is provided in Section 1.9.1, “Part Numbers Fully Addressed by This Document.” Section 1.9.2, “Part Numbers Not Fully Addressed by This Document,” lists the part numbers which do not fully conform to the specifications of this document. These special part numbers require an additional document called a part number specification.

1.9.1 Part Numbers Fully Addressed by This Document

Table 20 provides the Motorola part numbering nomenclature for the MPC107. Note that the individual part numbers correspond to a maximum processor core frequency. For available frequencies, contact your local Motorola sales office. In addition to the processor frequency, the part numbering scheme also includes an application modifier which may specify special application conditions. Each part number also contains a revision code which refers to the die mask revision number. The revision level can be determined by reading the Revision ID register at address offset 0x08.

Table 20. Part Numbering Nomenclature

XPC	*nnn*	*x*	*xx*	*nnn*	*x*	*x*
Product Code	**Part Identifier**	**Process Descriptor**	**Package [1]**	**Frequency [2] (MHz)**	**Application Modifier**	**Revision Level**
XPC	107	A	PX = PBGA	100	L: 2.5 V ± 125 mV 0° to 105°C	C:1.3; Rev. ID:0x13 D:1.4; Rev. ID:0x14

Notes:
1. See Section 1.5, “Package Description,” for more information on available package types.
2. Processor core frequencies supported by parts addressed by this specification only. Not all parts described in this specification support all core frequencies. Additionally, parts addressed by part number specifications may support other maximum core frequencies.

1.9.2 Part Numbers Not Fully Addressed by This Document

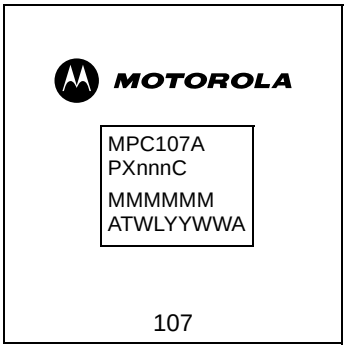
Parts with application modifiers or revision levels not fully addressed in this specification document are described in separate part number specifications which supplement and supersede this document; see Table 21.

Table 21. Part Numbers Addressed by XPC107APX*nnn*W*x* Series Part Number Specification (Document Order No. MPC107APXPNS/D)

XPC	*nnn*	A	*Px*	*nnn*	W	*x*
Product Code	**Part Identifier**	**Part Modifier**	**Package**	**Frequency (MHz)**	**Process Descriptor**	**Revision Level**
XPC	107	A	PX = PBGA	133	W: 2.7 V ± 100 mV 0° to 85°C	D:1.4; Rev. ID:0x14

1.9.3 Part Marking

Parts are marked as the example shown in Figure 30.



FC-PBGA

Notes:
MMMMMM is the 6-digit mask number.
ATWLYYWWA is the traceability code.
CCCCC is the country of assembly. This space is left blank if parts are assembled in the United States.

Figure 30. Motorola Part Marking for PBGA Devices

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