



### Advance Information

# **MPC7400 RISC Microprocessor Hardware Specifications**

The MPC7400 is an implementation of the PowerPC<sup>TM</sup> family of reduced instruction set computing (RISC) microprocessors. This document describes pertinent electrical and physical characteristics of the MPC7400. For functional characteristics of the processor, refer to the MPC7400 RISC Microprocessor User's Manual.

This document contains the following topics:

Topic	Page
Section 1.1, "Overview"	2
Section 1.2, "Features"	4
Section 1.3, "General Parameters"	7
Section 1.4, "Electrical and Thermal Characteristics"	7
Section 1.5, "Pin Assignments"	25
Section 1.6, "Pinout Listings"	26
Section 1.7, "Package Description"	29
Section 1.8, "System Design Information"	30
Section 1.9, "Document Revision History"	43
Section 1.10, "Ordering Information"	43

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

This document contains information on a new product under development by Motorola. Motorola reserves the right to change or discontinue this product without notice.

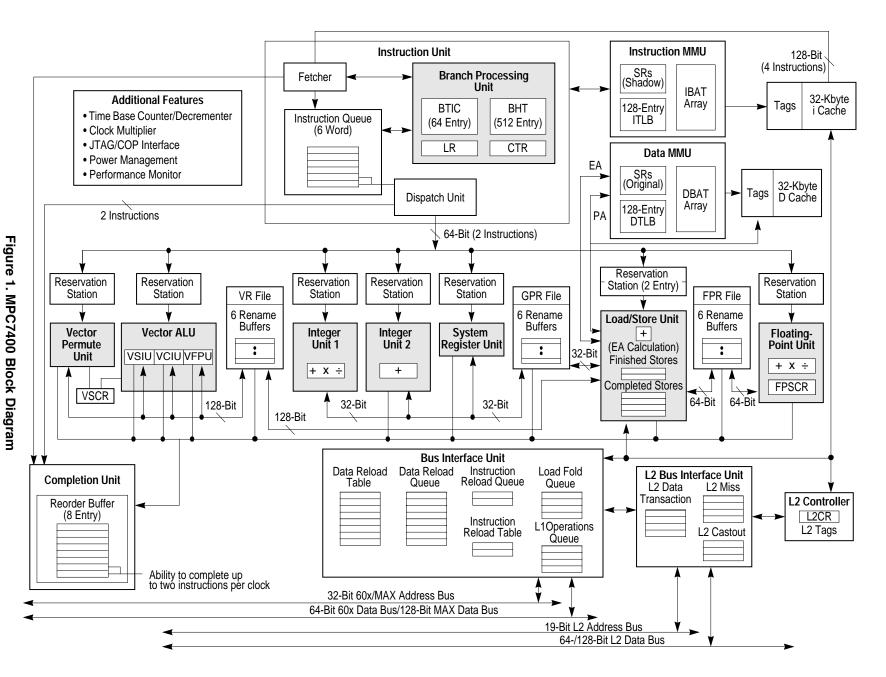


#### **Overview** 1.1

The MPC7400 is the first implementation of the fourth generation (G4) of PowerPC microprocessors from Motorola. The MPC7400 implements the full PowerPC 32-bit architecture and is targeted at both portable and computing systems applications. Some comments on the MPC7400 (with respect to MPC750):

- The MPC7400 adds an implementation of the new AltiVec<sup>™</sup> technology instruction set
- The MPC7400 includes significant improvements in memory subsystem (MSS) bandwidth and offers an optional, high-bandwidth MPX bus interface
- The MPC7400 adds full hardware-based multiprocessing capability, including a 5-state cache coherency protocol (4 MESI states plus a fifth state for shared intervention)
- The MPC7400 is implemented in a next generation process technology for core frequency improvement
- The MPC7400 floating-point unit has been improved to make latency equal for double-precision and single-precision operations involving multiplication
- The completion queue has been extended to 8 slots
- There are no other significant changes to scalar pipelines, decode/dispatch/completion mechanisms, or the branch unit. The MPC750's 4-stage pipeline model is unchanged (fetch, decode/dispatch, execute, complete/writeback)

Figure 1 shows a block diagram of the MPC7400.



### 1.2 Features

This section summarizes features of the MPC7400's implementation of the PowerPC architecture. Major features of the MPC7400 are as follows:

- Branch processing unit
  - Four instructions fetched per clock
  - One branch processed per cycle (plus resolving 2 speculations)
  - Up to 1 speculative stream in execution, 1 additional speculative stream in fetch
  - 512-entry branch history table (BHT) for dynamic prediction
  - 64-entry, 4-way set associative Branch Target Instruction Cache (BTIC) for eliminating branch delay slots
- Dispatch unit
  - Full hardware detection of dependencies (resolved in the execution units)
  - Dispatch two instructions to eight independent units (system, branch, load/store, fixed-point unit 1, fixed-point unit 2, floating-point, AltiVec permute, AltiVec ALU)
  - Serialization control (predispatch, postdispatch, execution serialization)
- Decode
  - Register file access
  - Forwarding control
  - Partial instruction decode
- Completion
  - 8 entry completion buffer
  - Instruction tracking and peak completion of two instructions per cycle
  - Completion of instructions in program order while supporting out-of-order instruction execution, completion serialization and all instruction flow changes
- Fixed-point units (FXUs) that share 32 GPRs for integer operands
  - Fixed-point unit 1 (FXU1)—multiply, divide, shift, rotate, arithmetic, logical
  - Fixed-point unit 2 (FXU2)—shift, rotate, arithmetic, logical
  - Single-cycle arithmetic, shifts, rotates, logical
  - Multiply and divide support (multi-cycle)
  - Early out multiply
- Three-stage floating-point unit and a 32-entry FPR file
  - Support for IEEE-754 standard single and double-precision floating-point arithmetic
  - 3 cycle latency, 1 cycle throughput (single or double precision)
  - Hardware support for divide
  - Hardware support for denormalized numbers
  - Time deterministic non-IEEE mode
- System unit
  - Executes CR logical instructions and miscellaneous system instructions
  - Special register transfer instructions
- AltiVec Unit
  - Full 128-bit data paths
  - Two dispatchable units: vector permute unit and vector ALU unit.
  - Contains its own 32-entry 128-bit vector register file (VRF) with 6 renames



#### **Features**

- The vector ALU unit is further sub-divided into the vector simple integer unit (VSIU), the vector complex integer unit (VCIU), and the vector floating-point unit (VFPU).
- Fully pipelined

### Load/store unit

- One cycle load or store cache access (byte, half word, word, double-word)
- 2 cycle load latency with 1 cycle throughput
- Effective address generation
- Hits under misses (multiple outstanding misses)
- Single-cycle unaligned access within double word boundary
- Alignment, zero padding, sign extend for integer register file
- Floating-point internal format conversion (alignment, normalization)
- Sequencing for load/store multiples and string operations
- Store gathering
- Executes the cache and TLB instructions
- Big- and little-endian byte addressing supported
- Misaligned little-endian supported
- Supports FXU, FPU, and AltiVec load/store traffic
- Complete support for all 4 architecture AltiVec DST streams

### • Level 1 (L1) cache structure

- 32K, 32-byte line, 8-way set associative instruction cache (iL1)
- 32K, 32-byte line, 8-way set associative data cache (dL1)
- Single-cycle cache access
- Pseudo least-recently-used (LRU) replacement
- Data cache supports AltiVec LRU and transient instructions algorithm
- Copy-back or write-through data cache (on a page per page basis)
- Supports all PowerPC memory coherency modes
- Non-blocking instruction and data cache
- Separate copy of data cache tags for efficient snooping
- No snooping of instruction cache except for ICBI instruction

### • Level 2 (L2) cache interface

- Internal L2 cache controller and tags; external data SRAMs
- 512K, 1M, and 2Mbyte 2-way set associative L2 cache support
- Copyback or write-through data cache (on a page basis, or for all L2)
- 32 byte (512K), 64 byte (1M), or 128 byte (2M) sectored line size
- Supports pipelined (register-register) synchronous burst SRAMs and pipelined (register-register) late-write synchronous burst SRAMs
- Core-to-L2 frequency divisors of  $\div 1$ ,  $\div 1.5$ ,  $\div 2$ ,  $\div 2.5$ ,  $\div 3$ ,  $\div 3.5$ , and  $\div 4$  supported
- 64 bit data bus
- Selectable interface voltages of 1.8, 2.5, and 3.3V.
- Memory management unit
  - 128 entry, 2-way set associative instruction TLB
  - 128 entry, 2-way set associative data TLB
  - Hardware reload for TLBs

- 4 instruction BATs and 4 data BATs
- Virtual memory support for up to 4 exabytes  $(2^{52})$  of virtual memory
- Real memory support for up to 4 gigabytes  $(2^{32})$  of physical memory
- Snooped and invalidated for TLBI instructions

#### Efficient data flow

- All data buses between VRF, load/store unit, dL1, iL1, L2, and the bus are 128-bits wide
- dL1 is fully pipelined to provide 128 bits/cycle to/from the VRF
- L2 is fully pipelined to provide 128 bits per L2 clock cycle to the L1s
- Up to 8 outstanding, out-of-order, cache misses between dL1 and L2/bus
- Up to 7 outstanding, out-of-order transactions on the bus
- Load folding to fold new dL1 misses into older, outstanding load and store misses to the same
- Store miss merging for multiple store misses to the same line. Only coherency action taken (i.e., address only) for store misses merged to all 32 bytes of a cache line (no data tenure needed).
- 2-entry finished store queue and 4-entry completed store queue between load/store unit and dL1
- Separate additional queues for efficient buffering of outbound data (castouts, write throughs, etc.) from dL1 and L2

#### Bus interface

- New MPX bus extension to 60X processor interface
- Mode-compatible with 60x processor interface
- 32-bit address bus
- 64 bit data bus
- Bus-to-core frequency multipliers of 2x, 2.5x, 3x, 3.5x, 4x, 4.5x, 5x, 5.5x, 6x, 6.5x, 7x, 7.5x, 8x supported
- Selectable interface voltages of 1.8 and 3.3V.

#### Power management

- Low-power design with thermal requirements very similar to MPC740 and MPC750.
- 1.8 volt processor core
- Selectable interface voltages below 3.3V can reduce power in output buffers
- Three static power saving modes: doze, nap, and sleep
- Dynamic power management

#### **Testability**

- LSSD scan design
- IEEE 1149.1 JTAG interface
- Array built-in self test (ABIST)—factory test only.
- Redundancy on L1 data arrays and L2 tag arrays
- Reliability and serviceability
  - Parity checking on 60x and L2 cache buses

### 1.3 General Parameters

The following list provides a summary of the general parameters of the MPC7400:

Technology  $0.20 \mu m$  CMOS, six-layer metal

Die size 7.86 mm x 10.58 mm (83 mm<sup>2</sup>)

Transistor count 10.5 million

Logic design Fully-static

Packages Surface mount 360 ceramic ball grid array (CBGA)

Core power supply:  $1.8V \pm 100 \text{ mV}$  dc (nominal; see Table 3 for recommended operating

conditions)

I/O power supply  $1.8V \pm 100 \text{ mV dc}$  or

 $2.5V \pm 100 \text{ mV}$  dc (L2 interface only) or

 $3.3V \pm 5\%$  (input thresholds are configuration pin selectable)

### 1.4 Electrical and Thermal Characteristics

This section provides the AC and DC electrical specifications and thermal characteristics for the MPC7400.

### 1.4.1 DC Electrical Characteristics

The tables in this section describe the MPC7400 DC electrical characteristics. Table 1 provides the absolute maximum ratings.

Table 1. Absolute Maximum Ratings<sup>1</sup>

Characteristic		Symbol	Maximum Value	Unit	Note
Core supply voltage		Vdd	-0.3 to 2.1	V	4
PLL supply voltage		AVdd	-0.3 to 2.1	V	4
L2 DLL supply voltage		L2AVdd	-0.3 to 2.1	V	4
Processor bus supply voltage	Processor bus supply voltage		-0.3 to 3.465	V	3
L2 bus supply voltage		L2OVdd	-0.3 to 3.465	V	3
Input voltage	Processor bus	V <sub>in</sub>	-0.3 to OVdd + 0.3V	V	2,5
	L2 Bus	V <sub>in</sub>	-0.3 to L2OVdd + 0.3V	V	2,5
	JTAG Signals	V <sub>in</sub>	-0.3 to 3.6	V	

Table 1. Absolute Maximum Ratings<sup>1</sup> (Continued)

Characteristic	Symbol	Maximum Value	Unit	Note
Storage temperature range	T <sub>stg</sub>	-55 to 150	ô	

#### Notes:

- 1. Functional and tested operating conditions are given in Table 3. 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. Caution: V<sub>in</sub> must not exceed OVdd or L2OVdd by more than 0.3V at any time including during power-on reset
- Caution: L2OVdd/OVdd must not exceed Vdd/AVdd/L2AVdd by more than 2.0V at any time including during power-on reset.
- 4. Caution: Vdd/AVdd/L2AVdd must not exceed L2OVdd/OVdd by more than 0.4V at any time including during power-on reset. In addition, operation at nominal Vdd/AVdd/L2AVdd greater than nominal L2OVdd or OVdd in the 1.8V input threshold select mode can cause erratic operation and AC timing values worse than described in this specification.
- 5. V<sub>in</sub> may overshoot/undershoot to a voltage and for a maximum duration as shown in Figure 2.

Figure 2 shows the undershoot and overshoot voltage on the MPC7400.

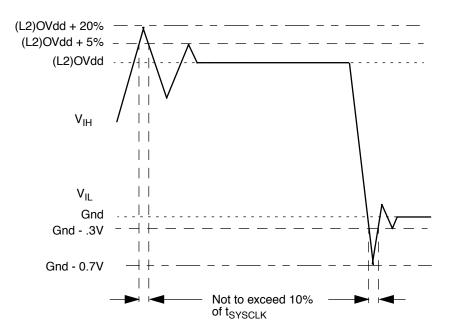


Figure 2. Overshoot/Undershoot Voltage

The MPC7400 provides several I/O voltages to support both compatibility with existing systems and migration to future systems. The MPC7400 "core" voltage must always be provided at nominal 1.8V (see Table 3 for actual recommended core voltage). Voltage to the L2 I/Os and processor interface I/Os are provided through separate sets of supply pins and may be provided at the voltages shown in Table 2. The input voltage threshold for each bus is selected by sampling the state of the voltage select pins at the negation of the signal  $\overline{\text{HRESET}}$ . The output voltage will swing from GND to the maximum voltage applied to the OVdd or L2OVdd power pins.

**Table 2. Input Threshold Voltage Setting** 

BVSEL Signal	Processor Bus Input Threshold is Relative to:	L2VSEL Signal	L2 Bus Input Threshold is Relative to:	Note
0	1.8V	0	1.8	1
HRESET	Not Applicable	HRESET	2.5	1,2
1	3.3V	1	3.3	1

#### Notes:

- 1. Caution: The input threshold selection must agree with the OVdd/L2OVdd voltages supplied.
- 2. To select the 2.5 volt threshold option, L2VSEL should be tied to HRESET so that the two signals change state together.

Table 3 provides the recommended operating conditions for the MPC7400.

**Table 3. Recommended Operating Conditions** 

Characte	eristic	Symbol	Recommended Value	Unit
Core supply voltage		Vdd	1.8v ± 100mv	V
PLL supply voltage		AVdd	1.8v ± 100mv	V
L2 DLL supply voltage		L2AVdd	1.8v ± 100mv	V
Processor bus supply	BVSEL = 0	OVdd	1.8v ± 100mv	V
voltage	BVSEL = 1	OVdd	3.3v ± 165mv	V
L2 bus supply voltage	L2VSEL = 0	L2OVdd	1.8v ± 100mv	V
	L2VSEL = HRESET	L2OVdd	2.5v ± 100mv	V
	L2VSEL = 1	L2OVdd	3.3v ± 165mv	V
Input voltage	Processor bus	V <sub>in</sub>	GND to OVdd	V
	L2 Bus	V <sub>in</sub>	GND to L2OVdd	V
	JTAG Signals	V <sub>in</sub>	GND to OVdd	V
Die-junction temperature		T <sub>j</sub>	0 to 105	°C

**Note:** These are the recommended and tested operating conditions. Proper device operation outside of these conditions is not guaranteed.

Table 4 provides the package thermal characteristics for the MPC7400.

**Table 4. Package Thermal Characteristics** 

Characteristic	Symbol	Value	Rating
CBGA package thermal resistance, junction-to-case thermal resistance (typical)	$\theta_{JC}$	0.03	°C/W
CBGA package thermal resistance, die junction-to-lead thermal resistance (typical)	$\theta_{JB}$	3.8	°C/W

Note: Refer to Section 1.8, "System Design Information," for more details about thermal management.

The MPC7400 incorporates a thermal management assist unit (TAU) composed of a thermal sensor, digital-to-analog converter, comparator, control logic, and dedicated special-purpose registers (SPRs). See the

MPC7400 RISC Microprocessor User's Manual for more information on the use of this feature. Specifications for the thermal sensor portion of the TAU are found in Table 5.

#### **Table 5. Thermal Sensor Specifications**

At recommended operating conditions (See Table 3)

Characteristic	Min	Max	Unit	Notes
Temperature range	0	128	°C	1
Comparator settling time	20	-	μs	2
Resolution	4		°C	3
Accuracy	-12	+12	°C	

#### Notes:

- 1. The temperature is the junction temperature of the die. The thermal assist unit's raw output does not indicate an absolute temperature, but it must be interpreted by software to derive the absolute junction temperature. For information about the use and calibration of the TAU, see Motorola application note, "Programming the Thermal Assist Unit in the MPC750 Microprocessor," (order #: AN1800/D).
- 2. The comparator settling time value must be converted into the number of CPU clocks that need to be written into the THRM3 SPR.
- 3. Guaranteed by design and characterization.

Table 6 provides the DC electrical characteristics for the MPC7400.

### **Table 6. DC Electrical Specifications**

At recommended operating conditions (See Table 3)

Characteristic	Nominal Bus Voltage <sup>1</sup>	Symbol	Min	Max	Unit	Notes
Input high voltage (all inputs except SYSCLK)	1.8	V <sub>IH</sub>	0.65 * (L2)OVdd	(L2)OVdd + 0.3	V	2,3
	2.5	V <sub>IH</sub>	1.7	L2OVdd + 0.3	٧	2,3,4
	3.3	V <sub>IH</sub>	2.0	(L2)OVdd + 0.3	٧	2,3
Input low voltage (all inputs except	1.8	V <sub>IL</sub>	-0.3	0.35 * OVdd	٧	
SYSCLK)	2.5	V <sub>IL</sub>	-0.3	0.2 * L2OVdd	٧	4
	3.3	V <sub>IL</sub>	-0.3	0.8	٧	
SYSCLK input high voltage	1.8	CVIH	1.5	OVdd + 0.3	٧	2
	3.3	CVIH	2.4	OVdd + 0.3	٧	2
SYSCLK input low voltage	1.8	CV <sub>IL</sub>	-0.3	0.2	٧	
	3.3	CV <sub>IL</sub>	-0.3	0.4	٧	
Input leakage current, V <sub>in</sub> = L2OVdd/ OVdd		I <sub>in</sub>	_	10	μΑ	2,3
Hi-Z (off-state) leakage current, V <sub>in</sub> = L2OVdd/OVdd		I <sub>TSI</sub>	_	10	μΑ	2,3,6

#### **Electrical and Thermal Characteristics**

**Table 6. DC Electrical Specifications (Continued)** 

At recommended operating conditions (See Table 3)

Characteristic	Nominal Bus Voltage <sup>1</sup>	Symbol	Min	Max	Unit	Notes
Output high voltage, I <sub>OH</sub> = -6 mA	1.8	V <sub>OH</sub>	(L2)OVdd- 0.45	_	V	
	2.5	V <sub>OH</sub>	1.7	_	٧	
	3.3	V <sub>OH</sub>	2.4	_	٧	
Output low voltage, I <sub>OL</sub> = 6 mA	1.8	V <sub>OL</sub>	_	0.45	٧	
	2.5	V <sub>OL</sub>	_	0.4	٧	
	3.3	V <sub>OL</sub>	_	0.4	٧	
Capacitance, V <sub>in</sub> = 0 V, f = 1 MHz		C <sub>in</sub>	_	7.5	pF	3,5

#### Notes:

- 1. Nominal voltages; See Table 3 for recommended operating conditions.
- 2. For processor bus signals, the reference is OVdd while L2OVdd is the reference for the L2 bus signals.
- 3. Excludes test signals (LSSD\_MODE, L1\_TSTCLK, L2\_TSTCLK) and IEEE 1149.1 boundary scan (JTAG) signals.
- 4. Applicable to L2 bus interface only.
- 5. Capacitance is periodically sampled rather than 100% tested.
- 6. The leakage is measured for nominal OVdd and Vdd, or both OVdd and Vdd must vary in the same direction (for example, both OVdd and Vdd vary by either +5% or -5%).

Table 7 provides the power consumption for the MPC7400.

**Table 7. Power Consumption for MPC7400** 

	Processor (Cl	PU) Frequency	Unit	Notes				
	350 MHz	400 MHz	Oilit	Notes				
Full-On Mode								
Typical	4.4	5.0	W	1, 3				
Maximum	10.9	11.5	W	1, 2				
Doze Mode		1	1					
Maximum	4.4	5.0	W	1, 2				
Nap Mode		1	1					
Maximum	1.75	2.0	W	1, 2				
Sleep Mode	•	'	1	1				
Maximum	1.75	2.0	W	1, 2				
Sleep Mode-PLL and DL	Sleep Mode—PLL and DLL Disabled							
Typical	600	600	mW	1, 3				

**Table 7. Power Consumption for MPC7400 (Continued)** 

	Processor (CF	PU) Frequency	Unit	Notes
	350 MHz	400 MHz	Ome	Notes
Maximum	1.0	1.0	W	1, 2

#### Notes:

- 1. These values apply for all valid processor bus and L2 bus ratios. The values do not include I/O Supply Power (OVdd and L2OVdd) or PLL/DLL supply power (AVdd and L2AVdd). OVdd and L2OVdd power is system dependent, but is typically <10% of Vdd power. Worst case power consumption for AVdd = 15 mw and L2AVdd = 15 mW.
- 2. Maximum power is measured at Vdd = 1.9V while running an entirely cacheresident, contrived sequence of instructions which keep the execution units, including AltiVec, maximally busy.
- 3. Typical power is an average value measured at Vdd = AVdd = L2AVdd = 1.8V, OVdd = L2OVdd = 3.3V in a system while running a codec application that is AltiVec intensive.

### 1.4.2 AC Electrical Characteristics

This section provides the AC electrical characteristics for the MPC7400. After fabrication, functional parts are sorted by maximum processor core frequency as shown in Section 1.4.2.1, "Clock AC Specifications," and tested for conformance to the AC specifications for that frequency. The processor core frequency is determined by the bus (SYSCLK) frequency and the settings of the PLL\_CFG[0-3] signals. Parts are sold by maximum processor core frequency; see Section 1.10, "Ordering Information."

#### **Clock AC Specifications** 1.4.2.1

Table 8 provides the clock AC timing specifications as defined in Figure 3.

**Table 8. Clock AC Timing Specifications** 

At recommended operating conditions (See Table 3)

Characteristic	Symbol	Max	imum Pr Freq	ocesso uency	r Core	Unit	Notes
	,	350	MHz	400 MHz			
		Min	Max	Min	Max		
Processor frequency	f <sub>core</sub>	175	350	200	400	MHz	1
VCO frequency	f <sub>VCO</sub>	350	700	400	800	MHz	1
SYSCLK frequency	f <sub>SYSCLK</sub>	25	100	25	133	MHz	1
SYSCLK cycle time	t <sub>SYSCLK</sub>	10	40	7.5	40	ns	
SYSCLK rise and fall	t <sub>KR</sub> & t <sub>KF</sub>	_	1.0	_	1.0	ns	2
time	t <sub>KR</sub> & t <sub>KF</sub>	_	0.5	_	0.5	ns	3
SYSCLK duty cycle measured at OVdd/2	t <sub>KHKL</sub> /t <sub>SYSCLK</sub>	40	60	40	60	%	4
SYSCLK jitter		_	±150	_	±150	ps	5

**Table 8. Clock AC Timing Specifications (Continued)** 

At recommended operating conditions (See Table 3)

Characteristic	Symbol	Maximum Processor Core Frequency					Unit	Notes
Onaradionolio	<b>GyG</b>	350 MHz		400 MHz			Holes	
		Min	Max	Min	Max			
Internal PLL relock time		_	100	_	100	μS	6	

#### Notes:

- Caution: The SYSCLK frequency and PLL\_CFG[0-3] settings must be chosen such that the resulting SYSCLK (bus) frequency, CPU (core) frequency, and PLL (VCO) frequency do not exceed their respective maximum or minimum operating frequencies. Refer to the PLL\_CFG[0-3] signal description in Section 1.8.1, "PLL Configuration," for valid PLL\_CFG[0-3] settings
- Rise and fall times for the SYSCLK input measured from 0.4V to 2.4V when OVdd = 3.3V nominal.
- 3. Rise and fall times for the SYSCLK input measured from 0.4V to 1.4V when OVdd = 1.8V nominal.
- 4. Timing is guaranteed by design and characterization.
- 5. This represents total input jitter—short term and long term combined—and is guaranteed by design.
- 6. Relock timing is guaranteed by design and characterization. PLL-relock time is the maximum amount of time required for PLL lock after a stable Vdd and SYSCLK are reached during the power-on reset sequence. This specification also applies when the PLL has been disabled and subsequently re-enabled during sleep mode. Also note that HRESET must be held asserted for a minimum of 255 bus clocks after the PLL-relock time during the power-on reset sequence.

Figure 3 provides the SYSCLK input timing diagram.

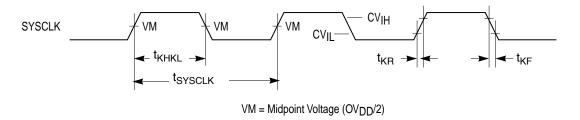


Figure 3. SYSCLK Input Timing Diagram

### 1.4.2.2 Processor Bus AC Specifications

Table 9 provides the processor bus AC timing specifications for the MPC7400 as defined in Figure 4 and Figure 5. Timing specifications for the L2 bus are provided in Section 1.4.2.3, "L2 Clock AC Specifications."y

### Table 9. Processor Bus AC Timing Specifications<sup>1</sup>

At Vdd=AVdd=1.8V $\pm$ 100mV; 0  $\leq$  Tj  $\leq$  105°C, OVdd = 3.3V $\pm$ 165mV and OVdd = 2.5V $\pm$ 100mV, Times for OVdd=1.8V±100mV are TBD

Parameter	Symbol <sup>2</sup>	350, 4	00 MHz	Unit	Notes
Parameter	Symbol	Min	Max	John	Notes
Mode select input setup to HRESET	t <sub>MVRH</sub>	8	_	t <sub>sysclk</sub>	3,4,5,6
HRESET to mode select input hold	t <sub>MXRH</sub>	0	_	ns	2,3,5
Setup Times:				ns	
Address/Transfer Attribute	t <sub>AVKH</sub>	1.6	_		7
Transfer Start (TS)	t <sub>TSVKH</sub>	1.6	_		-
Data/Data Parity	t <sub>DVKH</sub>	1.6	_		8
ARTRY/SHD0/SHD1	<sup>t</sup> ARVKH	1.6	-		-
All Other Inputs	t <sub>IVKH</sub>	1.6	-		9
Input Hold Times:				ns	
Address/Transfer Attribute	t <sub>AXKH</sub>	0	_		7
Transfer Start (TS)	t <sub>TSXKH</sub>	0	_		-
Data/Data Parity	t <sub>DXKH</sub>	0	_		8
ARTRY/SHD0/SHD1	t <sub>ARXKH</sub>	0	_		-
All Other Inputs	$t_{IXKH}$	0	_		9
Valid Times:				ns	
Address/Transfer Attribute	$t_{KHAV}$	_	3.2		7
TS, ABB, DBB	t <sub>KHTSV</sub>	_	3.4		_
Data	$t_{KHDV}$	_	3.5		8
Data Parity	$t_{KHDPV}$	_	3.5		8
ARTRY/SHD0/SHD1	t <sub>KHARV</sub>	_	2.5		_
All Other Outputs	t <sub>KHOV</sub>	_	3.2		10
Output Hold Times:				ns	
Address/Transfer Attribute	$t_{KHAX}$	0.75	_		7
TS, ABB, DBB	t <sub>KHTSX</sub>	0.75	_		-
Data/Data Parity	$t_{KHDX}$	0.6	–		8
ARTRY/SHD0/SHD1	t <sub>KHARX</sub>	0.75	-		-
All Other Outputs	t <sub>KHOX</sub>	0.75	_		10
SYSCLK to Output Enable	t <sub>KHOE</sub>	0.5	_	ns	
SYSCLK to Output High Impedance (all except TS, ABB/AMON(0), ARTRY/SHD, DBB/DMON(0) )	t <sub>KHOZ</sub>	_	4.0	ns	
SYSCLK to TS, ABB/AMON(0), DBB/DMON(0) High Impedance after precharge	t <sub>KHABPZ</sub>	_	1.0	t	5,11,13
Maximum Delay to ARTRY/SHD0/SHD1 Precharge	t <sub>KHARP</sub>	_	1	t <sub>sysclk</sub>	5,12, 13
SYSCLK to ARTRY/SHD0/SHD1 High Impedance After Precharge	t <sub>KHARPZ</sub>	_	2	tsysclk	5,12, 13

#### **Electrical and Thermal Characteristics**

### Table 9. Processor Bus AC Timing Specifications<sup>1</sup> (Continued)

At Vdd=AVdd=1.8V $\pm$ 100mV; 0  $\leq$  Tj  $\leq$  105°C, OVdd = 3.3V $\pm$ 165mV and OVdd = 2.5V $\pm$ 100mV, Times for OVdd=1.8V $\pm$ 100mV are TBD

Parameter	Symbol <sup>2</sup>	350, 40	00 MHz	Unit	Notes
Farameter	Symbol	Min	Max	Oille	Notes

#### Notes:

- 1. All input specifications are measured from the midpoint of the signal in question to the midpoint of the rising edge of the input SYSCLK. All output specifications are measured from the midpoint of the rising edge of SYSCLK to the midpoint of the signal in question. All output timings assume a purely resistive 50 ohm load (See Figure 4). Input and output timings are measured at the pin;time-of-flight delays must be added for trace lengths, vias, and connectors in the system.
- 2. The symbology used for timing specifications herein follows the pattern of t<sub>(signal)(state)</sub>(reference)(state)</sub> for inputs and t<sub>(reference)(state)</sub>(signal)(state)</sub> for outputs. For example, t<sub>IVKH</sub> symbolizes the time input signals (I) reach the valid state (V) relative to the SYSCLK reference (K) going to the high(H) state or input setup time. And t<sub>KHOV</sub> symbolizes the time from SYSCLK(K) going high(H) until outputs (O) are valid (V) or output valid time. Input hold time can be read as the time that the input signal (I) went invalid (X) with respect to the rising clock edge (KH) note the position of the reference and its state for inputs -and output hold time can be read as the time from the rising edge (KH) until the output went invalid (OX). For additional explanation of AC timing specifications in Motorola PowerPC microprocessors, see the application note "Understanding AC Timing Specifications for PowerPC Microprocessors."
- 3. The setup and hold time is with respect to the rising edge of HRESET (see Figure 5).
- 4. This specification is for configuration mode select only. Also note that the HRESET must be held asserted for a minimum of 255 bus clocks after the PLL re-lock time during the power-on reset sequence.
- 5. t<sub>sysclk</sub> is the period of the external clock (SYSCLK) in nanoseconds (ns). The numbers given in the table must be multiplied by the period of SYSCLK to compute the actual time duration (in nanoseconds) of the parameter in question.
- 6. Mode select signals are BVSEL, EMODE, L2VSEL, PLL\_CFG[0-3]
- 7. Address/Transfer Attribute signals are composed of the following—A[0–31], AP[0–3], TT[0–4], TBST, TSIZ[0–2], GBL, WT, CI
- 8. Data signals are composed of the following—DH[0-31], DL[0-31]; Data Parity signals are composed of DP[0-7].
- 9. All other input signals are composed of the following— AACK, BG, CKSTP\_IN, DBG, DBWO/DTI[0], DTI[1-2], HRESET, INT, MCP, QACK, SMI, SRESET, TA, TBEN, TEA, TLBISYNC.
- 10. All other output signals are composed of the following BR, CKSTP OUT, DRDY, HIT, QREQ, RSRV
- 11. According to the 60x bus protocol,  $\overline{TS}$ ,  $\overline{ABB}$  and  $\overline{DBB}$  are driven only by the currently active bus master. They are asserted low then precharged high before returning to high-Z as shown in Figure 6. The nominal precharge width for  $\overline{TS}$ ,  $\overline{ABB}$  or  $\overline{DBB}$  is 0.5\*  $t_{SYSCLK}$ , i.e. less than the minimum  $t_{SYSCLK}$  period, to ensure that another master asserting  $\overline{TS}$ ,  $\overline{ABB}$ , or  $\overline{DBB}$  on the following clock will not contend with the precharge. Output valid and output hold timing is tested for the signal asserted. Output valid time is tested for precharge. The high-Z behavior is guaranteed by design.
- 12. According to the 60x bus protocol,  $\overline{ARTRY}$  can be driven by multiple bus masters through the clock period immediately following  $\overline{AACK}$ . Bus contention is not an issue since any master asserting  $\overline{ARTRY}$  will be driving it low. Any master asserting it low in the first clock following  $\overline{AACK}$  will then go to high-Z for one clock before precharging it high during the second cycle after the assertion of  $\overline{AACK}$ . The nominal precharge width for  $\overline{ARTRY}$  is 1.0  $t_{sysclk}$ ; i.e. it should be high-Z as shown in Figure 6 before the first opportunity for another master to assert  $\overline{ARTRY}$ . Output valid and output hold timing is tested for the signal asserted. Output valid time is tested for precharge. The high-Z behavior is guaranteed by design.
- 13. Guaranteed by design and not tested.

Figure 4 provides the AC test load for the MPC7400.

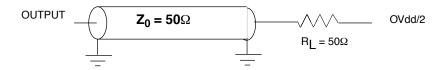
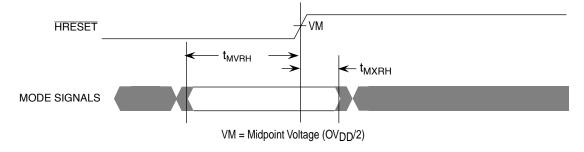


Figure 4. AC Test Load

Figure 5 provides the mode select input timing diagram for the MPC7400.



**Figure 5. Mode Input Timing Diagram** 

### **Electrical and Thermal Characteristics**

Figure 6 provides the input/output timing diagram for the MPC7400.

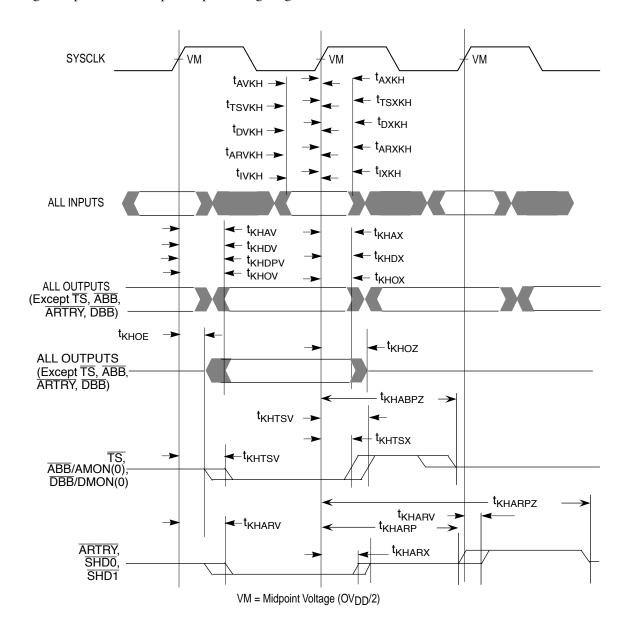


Figure 6. Input/Output Timing Diagram

### 1.4.2.3 L2 Clock AC Specifications

The L2CLK frequency is programmed by the L2 Configuration Register (L2CR[4:6]) core-to-L2 divisor ratio. See Table 15 for example core and L2 frequencies at various divisors. Table 10 provides the potential range of L2CLK output AC timing specifications as defined in Figure 7.

The L2SYNC OUT signal is intended to be routed halfway out to the SRAMs and then returned to the L2SYNC IN input of the MPC7400 to synchronize L2CLKOUT at the SRAM with the processor's internal clock. L2CLKOUT at the SRAM can be offset forward or backward in time by shortening or lengthening the routing of L2SYNC OUT to L2SYNC IN. See Motorola Application Note AN179/D "PowerPC™ Backside L2 Timing Analysis for the PCB Design Engineer."

The minimum L2CLK frequency of Table 10 is specified by the maximum delay of the internal DLL. The variable-tap DLL introduces up to a full clock period delay in the L2CLKOUTA, L2CLKOUTB, and L2SYNC OUT signals so that the returning L2SYNC IN signal is phase aligned with the next core clock (divided by the L2 divisor ratio). Do not choose a core-to-L2 divisor which results in an L2 frequency below this minimum, or the L2CLKOUT signals provided for SRAM clocking will not be phase aligned with the MPC7400 core clock at the SRAMs.

The maximum L2CLK frequency shown in Table 10 is the core frequency divided by one. Very few L2 SRAM designs will be able to operate in this mode. Most designs will select a greater core-to-L2 divisor to provide a longer L2CLK period for read and write access to the L2 SRAMs. The maximum L2CLK frequency for any application of the MPC7400 will be a function of the AC timings of the MPC7400, the AC timings for the SRAM, bus loading, and printed circuit board trace length.

Motorola is similarly limited by system constraints and cannot perform tests of the L2 interface on a socketed part on a functional tester at the maximum frequencies of Table 10. Therefore functional operation and AC timing information are tested at core-to-L2 divisors of 2 or greater.

L2 input and output signals are latched or enabled respectively by the internal L2CLK (which is SYSCLK multiplied up to the core frequency and divided down to the L2CLK frequency). In other words, the AC timings of Table 11 are entirely independent of L2SYNC\_IN. In a closed loop system, where L2SYNC\_IN is driven through the board trace by L2SYNC OUT, L2SYNC IN only controls the output phase of L2CLKOUTA and L2CLKOUTB which are used to latch or enable data at the SRAMs. However, since in a closed loop system L2SYNC IN is held in phase alignment with the internal L2CLK, the signals of Table 11 are referenced to this signal rather than the not-externally-visible internal L2CLK. During manufacturing test, these times are actually measured relative to SYSCLK.

**Table 10. L2CLK Output AC Timing Specifications** 

At recommended operating conditions (See Table 3)

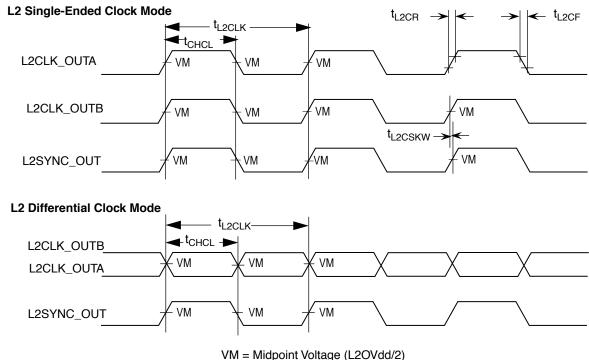
Parameter	Symbol	350	350 MHz		MHz	Unit	Notes
Farameter	<b>Cy</b> 201	Min	Max	Min	Max	)	Notes
L2CLK frequency	f <sub>L2CLK</sub>	100	350	133	400	MHz	1,4
L2CLK cycle time	t <sub>L2CLK</sub>	2.86	10	2.5	7.5	ns	
L2CLK duty cycle	t <sub>CHCL</sub> /t <sub>L2CLK</sub>	5	50	50		%	2
Internal DLL-relock time		640	_	640	_	L2CLK	3
DLL capture window		0	10	0	10	ns	5
L2CLKOUT output-to- output skew	t <sub>L2CSKW</sub>		50		50	ps	6
L2CLKOUT output jitter			±150		±150	ps	6

#### **Electrical and Thermal Characteristics**

#### Notes:

- 1. L2CLK outputs are L2CLK\_OUTA, L2CLK\_OUTB, and L2SYNC\_OUT pins. The L2CLK frequency to core frequency settings must be chosen such that the resulting L2CLK frequency and core frequency do not exceed their respective maximum or minimum operating frequencies. The maximum L2LCK frequency will be system dependent.. L2CLK\_OUTA and L2CLK\_OUTB must have equal loading.
- 2. The nominal duty cycle of the L2CLK is 50% measured at midpoint voltage.
- 3. The DLL re-lock time is specified in terms of L2CLKs. The number in the table must be multiplied by the period of L2CLK to compute the actual time duration in nanoseconds. Re-lock timing is guaranteed by design and characterization.
- 4. The L2CR[L2SL] bit should be set for L2CLK frequencies less than 110 MHz. This adds more delay to each tap of the DLL.
- 5. Allowable skew between L2SYNC\_OUT and L2SYNC\_IN.
- 6. Guaranteed by design and not tested. This output jitter number represents the maximum delay of one tap forward or one tap back from the current DLL tap as the phase comparator seeks to minimize the phase difference between L2SYNC\_IN and the internal L2CLK. This number must be comprehended in the L2 timing analysis. The input jitter on SYSCLK affects L2CLKOUT and the L2 address/data/control signals equally and therefore is already comprehended in the AC timing and does not have to be considered in the L2 timing analysis.

The L2CLK\_OUT timing diagram is shown in Figure 7.



VIVI = IVIIapoliti Voltage (EZOVaa/Z)

Figure 7. L2CLK OUT Output Timing Diagram

### 1.4.2.4 L2 Bus AC Specifications

Table 11 provides the L2 bus interface AC timing specifications for the MPC7400 as defined in Figure 8 and Figure 9 for the loading conditions described in Figure 10.

#### Table 11. L2 Bus Interface AC Timing Specifications

At Vdd=AVdd=L2AVdd=1.8V±100mV; 0 < Tj < 105°C, L2OVdd = 3.3V±165mV and L2OVdd = 2.5V±100mV, Times for L2OVdd=1.8V±100mV are

Parameter	Symbol	350, MI		Unit	Notes
		Min	Max		
L2SYNC_IN rise and fall time	t <sub>L2CR</sub> & t <sub>L2CF</sub>	_	1.0	ns	1
Setup Times:				ns	2
Data and parity	t <sub>DVL2CH</sub>	1.5	_		
Input Hold Times:				ns	2
Data and parity	t <sub>DXL2CH</sub>	_	0.0		
Valid Times:	t <sub>L2CHOV</sub>			ns	3,4
All outputs when L2CR[14-15] = 00		- -	2.5 3.0		
All outputs when L2CR[14-15] = 01		_	3.5		
All outputs when L2CR[14-15] = 10		-	4.0		
All outputs when L2CR[14-15] = 11					
Output Hold Times	t <sub>L2CHOX</sub>			ns	3
All outputs when L2CR[14-15] = 00		0.6 1.0	-		
All outputs when L2CR[14-15] = 01		1.4	_		
All outputs when L2CR[14-15] = 10		1.8	-		
All outputs when L2CR[14-15] = 11					
L2SYNC_IN to high impedance:	t <sub>L2CHOZ</sub>			ns	
All outputs when L2CR[14-15] = 00		-	2.0 2.5		
All outputs when L2CR[14-15] = 01		_	3.0		
All outputs when L2CR[14-15] = 10		-	3.5		
All outputs when L2CR[14-15] = 11					

#### Notes:

- 1. Rise and fall times for the L2SYNC\_IN input are measured from 20% to 80% of L2OVdd.
- 2. All input specifications are measured from the midpoint of the signal in question to the midpoint voltage of the rising edge of the input L2SYNC\_IN (see Figure 8). Input timings are measured at the pins.
- 3. All output specifications are measured from the midpoint voltage of the rising edge of L2SYNC\_IN to the midpoint of the signal in question. The output timings are measured at the pins. All output timings assume a purely resistive 50 ohm load (See Figure 10).
- 4. The outputs are valid for both single-ended and differential L2CLK modes. For pipelined registered synchronous burst RAMs, L2CR[14-15] = 00 is recommended. For pipelined late-write synchronous burst SRAMs, L2CR[14-15] = 10 is recommended.

### **Electrical and Thermal Characteristics**

Figure 8 shows the L2 bus input timing diagrams for the MPC7400.

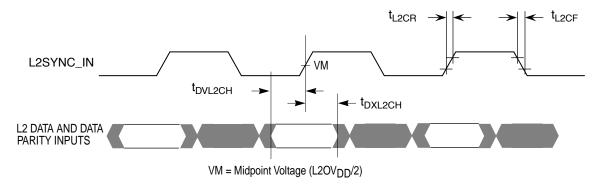


Figure 8. L2 Bus Input Timing Diagrams

Figure 9 shows the L2 bus output timing diagrams for the MPC7400.

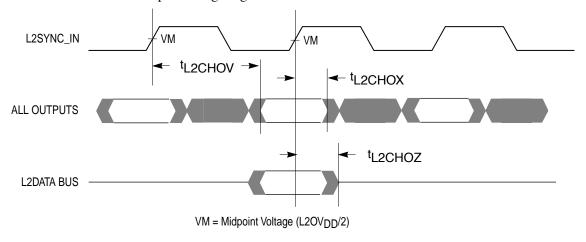


Figure 9. L2 Bus Output Timing Diagrams

Figure 10 provides the AC test load for L2 interface of the MPC7400.

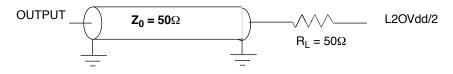


Figure 10. AC Test Load for the L2 Interface

### 1.4.2.5 IEEE 1149.1 AC Timing Specifications

Table 12 provides the IEEE 1149.1 (JTAG) AC timing specifications as defined in Figure 12, Figure 13, Figure 14, and Figure 15.

Table 12. JTAG AC Timing Specifications (Independent of SYSCLK)<sup>1</sup>

At recommended operating conditions (See Table 3)

Parameter		Symbol	Min	Max	Unit	Notes
TCK frequency of operation		f <sub>TCLK</sub>	0	33.3	MHz	
TCK cycle time		t <sub>TCLK</sub>	30	<b> </b>	ns	
TCK clock pulse width measured at 1.4V	t <sub>JHJL</sub>	15	-	ns		
TCK rise and fall times		t <sub>JR</sub> & t <sub>JF</sub>	0	2	ns	
TRST assert time		t <sub>TRST</sub>	25	<b> </b>	ns	2
Input Setup Times:					ns	
Boundary-s	can data	t <sub>DVJH</sub>	4	-		3
ן	MS, TDI	t <sub>IVJH</sub>	0	-		
Input Hold Times:					ns	
Boundary-s	can data	t <sub>DXJH</sub>	20	-		3
Т	MS, TDI	t <sub>IXJH</sub>	25	-		
Valid Times:					ns	
Boundary-s	can data	t <sub>JLDV</sub>	4	20		4
	TDO	t <sub>JLOV</sub>	4	25		
Output Hold Times:						
Boundary-s	can data	t <sub>JLDX</sub>				
	TDO	t <sub>JLOX</sub>				
TCK to output high impedance:					ns	
Boundary-s	can data	t <sub>JLDZ</sub>	3	19		4,5
	TDO	t <sub>JLOZ</sub>	3	9		5

#### Notes:

- 1. All outputs are measured from the midpoint voltage of the falling/rising edge of TCLK to the midpoint of the signal in question. The output timings are measured at the pins. All output timings assume a purely resistive 50 ohm load (See Figure 11). Time-of-flight delays must be added for trace lengths, vias, and connectors in the system.
- 2. TRST is an asynchronous level sensitive signal. The setup time is for test purposes only.
- 3. Non-JTAG signal input timing with respect to TCK.
- 4. Non-JTAG signal output timing with respect to TCK.
- 5. Guaranteed by design and characterization.

Figure 11 provides the AC test load for TDO and the boundary-scan outputs of the MPC7400.

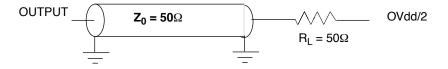


Figure 11. Alternate AC Test Load for the JTAG Interface

### **Electrical and Thermal Characteristics**

Figure 12 provides the JTAG clock input timing diagram.

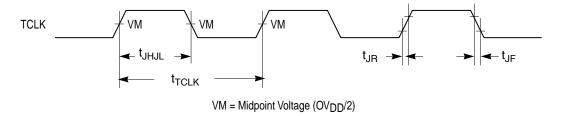


Figure 12. JTAG Clock Input Timing Diagram

Figure 13 provides the TRST timing diagram.

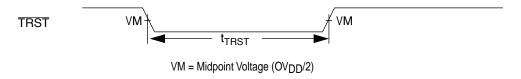


Figure 13. TRST Timing Diagram

Figure 14 provides the boundary-scan timing diagram.

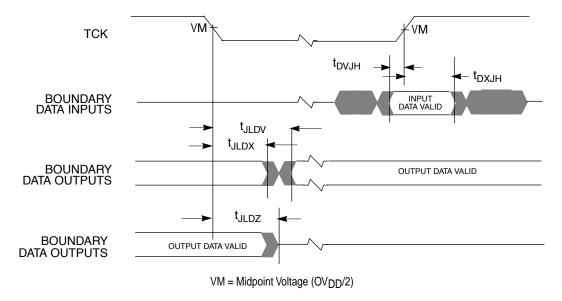


Figure 14. Boundary-Scan Timing Diagram

Figure 15 provides the test access port timing diagram.

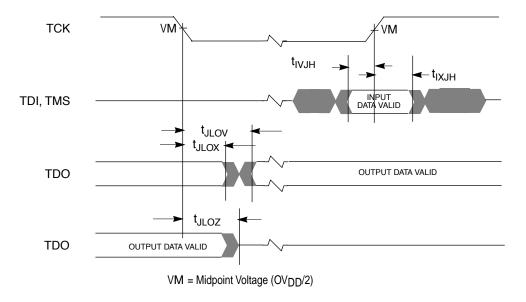
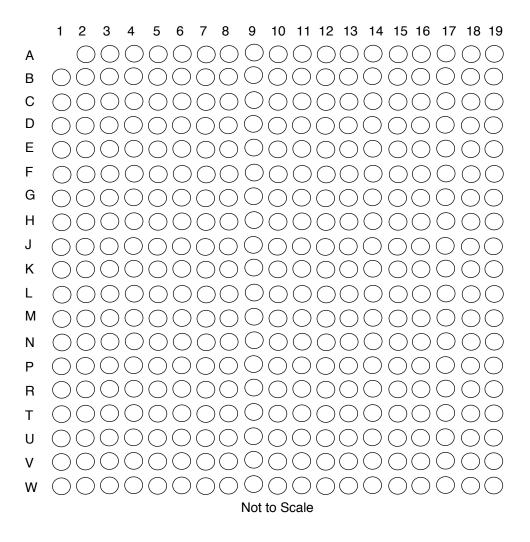


Figure 15. Test Access Port Timing Diagram

# 1.5 Pin Assignments

Figure 16 (in part A) shows the pinout of the MPC7400, 360 CBGA package as viewed from the top surface. Part B shows the side profile of the CBGA package to indicate the direction of the top surface view.

#### Part A



Part B

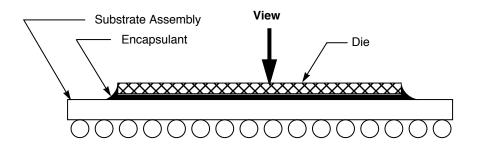


Figure 16. Pinout of the MPC7400, 360 CBGA Package as Viewed from the Top Surface

# 1.6 Pinout Listings

Table 13 provides the pinout listing for the MPC7400, 360 CBGA package.

Table 13. Pinout Listing for the MPC7400, 360 CBGA Package

				I/F Vol	tages Sup	ported <sup>1</sup>	
Signal Name	Pin Number	Active	I/O	1.8v	2.5v	3.3v	Notes
A[0-31]	A13, D2, H11, C1, B13, F2, C13, E5, D13, G7, F12, G3, G6, H2, E2, L3, G5, L4, G4, J4, H7, E1, G2, F3, J7, M3, H3, J2, J6, K3, K2, L2	High	I/O	V	_	V	
AACK	N3	Low	Input	√	_	√	
ABB AMON(0)	L7	Low	Output	V	_	√	12
AP[0-3]	C4, C5, C6, C7	High	I/O	√	_	√	
ARTRY	L6	Low	I/O	√	_	√	
AVDD	A8	_	Input	1.8V	1.8V	1.8V	
BG	H1	Low	Input	√	_	√	
BR	E7	Low	Output	√	_	√	
BVSEL	W1	High	Input	GND	N/A	3.3V	3, 8, 9
CHK	K11	Low	Input	√	_	√	4, 8, 9
CI	C2	Low	I/O	√	_	√	
CKSTP_IN	B8	Low	Input	√	_	√	
CKSTP_OUT	D7	Low	Output	√	_	√	
CLK_OUT	E3	High	Output	√	_	V	
DBB  DMON(0)	K5	Low	Output	V	_	√	12
DBG	K1	Low	Input	√	_	V	
DH[0-31]	W12, W11, V11, T9, W10, U9, U10, M11, M9, P8, W7, P9, W9, R10, W6, V7, V6, U8, V9, T7, U7, R7, U6, W5, U5, W4, P7, V5, V4, W3, U4, R5	High	I/O	√	_	√	
DL[0-31]	M6, P3, N4, N5, R3, M7, T2, N6, U2, N7, P11, V13, U12, P12, T13, W13, U13, V10, W8, T11, U11, V12, V8, T1, P1, V1, U1, N1, R2, V3, U3, W2	High	I/O	√	_	√	
DP[0-7]	L1, P2, M2, V2, M1, N2, T3, R1	High	I/O	√	_	√	
DRDY	K9	Low	Output	√	_	√	6, 8, 13
DBWO DTI[0]	D1	Low	Input	V	_	<b>√</b>	
DTI[1-2])	H6, G1	High	Input	√	_	√	10, 13

### **Pinout Listings**

Table 13. Pinout Listing for the MPC7400, 360 CBGA Package (Continued)

				I/F Vo			
Signal Name	Pin Number	Active	I/O	1.8v	2.5v	3.3v	Notes
EMODE	A3	Low	Input	V	_	V	7, 10
GBL	B1	Low	I/O	√	_	√	
GND	D10, D14, D16, D4, D6, E12, E8, F4, F6, F10, F14, F16, G9, G11, H5, H8, H10, H12, H15, J9, J11, K4, K6, K8, K10, K12, K14, K16, L9, L11, M5, M8, M10, M12, M15, N9, N11, P4, P6, P10, P14, P16, R8, R12, T4, T6, T10, T14, T16	_	_	GND	GND	GND	
HIT	B5	Low	Output	V	_	V	6, 8
HRESET	B6	Low	Input	V	_	V	
ĪNT	C11	Low	Input	V	_	V	
L1_TSTCLK	F8	High	Input	√	_	√	2
L2ADDR[0-16]	L17, L18, L19, M19, K18, K17, K15, J19, J18, J17, J16, H18, H17, J14, J13, H19, G18	High	Output	V	V	V	
L2ADDR[17]	K19	High	Output	√	√	√	8
L2ASPARE	W19	High	Output	√	√	√	8
L2AVDD	L13	_	Input	1.8V	1.8V	1.8V	
L2CE	P17	Low	Output	√	√	√	
L2CLKOUTA	N15	High	Output	√	√	√	
L2CLKOUTB	L16	High	Output	√	√	√	
L2DATA[0-63]	U14, R13, W14, W15, V15, U15, W16, V16, W17, V17, U17, W18, V18, U18, V19, U19, T18, T17, R19, R18, R17, R15, P19, P18, P13, N14, N13, N19, N17, M17, M13, M18, H13, G19, G16, G15, G14, G13, F19, F18, F13, E19, E18, E17, E15, D19, D18, D17, C18, C17, B19, B18, B17, A18, A17, A16, B16, C16, A14, A15, C15, B14, C14, E13	High	I/O	√	√	V	
L2DP[0-7]	V14, U16, T19, N18, H14, F17, C19, B15	High	I/O	√	V	V	
L2OVDD	D15, E14, E16, H16, J15, L15, M16, K13, P15, R14, R16, T15, F15	_	_	1.8V	2.5V	3.3V	11
L2SYNC_IN	L14	High	Input	√	√	√	
L2SYNC_OUT	M14	High	Output	√	√	√	
L2_TSTCLK	F7	High	Input	√	_	√	2
L2VSEL	A19	High	Input	GND	HRESET	3.3V	1, 3, 8, 9

Table 13. Pinout Listing for the MPC7400, 360 CBGA Package (Continued)

				I/F Vol	tages Sup	ported <sup>1</sup>	
Signal Name	Pin Number	Active	I/O	1.8v	2.5v	3.3v	Notes
L2WE	N16	Low	Output	√	V	√	
L2ZZ	G17	High	Output	V	V	√	
LSSD_MODE	F9	Low	Input	V	_	√	2
MCP	B11	Low	Input	V	_	√	
OVDD	D5, D8, D12, E4, E6, E9, E11, F5, H4, J5, L5, M4, P5, R4, R6, R9, R11, T5, T8, T12	_	_	1.8V	_	3.3V	
PLL_CFG[0-3]	A4, A5, A6, A7	High	Input	√	_	√	
QACK	B2	Low	Input	V	_	√	
QREQ	J3	Low	Output	√	_	√	
RSRV	D3	Low	Output	√	_	√	
SHD0	B3	Low	I/O	√	_	√	5, 8
SHD1	B4	Low	I/O	√	_	√	5, 8
SMI	A12	Low	Input	√	_	√	
SRESET	E10	Low	Input	√	_	√	
SYSCLK	H9	_	Input	√	_	√	
TA	F1	Low	Input	V	_	√	
TBEN	A2	High	Input	V	_	√	
TBST	A11	Low	Output	√	_	√	
TCK	B10	High	Input	V	_	√	
TDI	B7	High	Input	V	_	√	9
TDO	D9	High	Output	V	_	√	
TEA	J1	Low	Input	V	_	√	
TMS	C8	High	Input	V	_	√	9
TRST	A10	Low	Input	V	_	√	9
TS	K7	Low	I/O	V	_	√	
TSIZ[0-2]	A9, B9, C9	High	Output	V	_	√	
TT[0-4]	C10, D11, B12, C12, F11	High	I/O	V	_	√	
WT	C3	Low	I/O	V	_	√	
VDD	G8, G10, G12, J8, J10, J12, L8, L10, L12, N8, N10, N12	-	-	1.8V	1.8V	1.8V	

### **Package Description**

#### Notes:

- 1. OVdd supplies power to the processor bus, JTAG, and all control signals except the L2 cache controls (\overline{L2CE}, \overline{L2WE}, and \overline{L2ZZ}); L2OVDD supplies power to the L2 cache interface (L2ADDR[0-16], L2ASPARE, L2DATA[0-63], L2DP[0-7] and L2SYNC-OUT) and the L2 control signals; and Vdd supplies power to the processor core and the PLL and DLL (after filtering to become AVDD and L2AVDD respectively). These columns serve as a reference for the nominal voltage supported on a given signal as selected by the BVSEL/L2VSEL pin configurations of Table 2 and the voltage supplied. For actual recommended value of Vin or supply voltages see Table 3.
- 2. These are test signals for factory use only and must be pulled up to OVdd for normal machine operation.
- 3. To allow for future I/O voltage changes, provide the option to connect BVSEL and L2VSEL independently to either OVDD (selects 3.3v), OGND (selects 1.8v), or to HRESET (selects 2.5v). The L2 bus supports all 3 options. The processor bus only supports the 3.3v and 1.8v options.
- 4. Connect to HRESET to trigger post power-on-reset (por) internal memory test.
- 5. Ignored in 60x bus mode.
- 6. Unused output in 60x bus mode.
- 7. Deasserted (pulled high) at HRESET for 60x bus mode.
- 8. Uses one of 9 existing no-connects in MPC750's 360-BGA package.
- 9. Internal pull up on die.
- 10. Reuses MPC750's DRTRY, DBDIS, and TLBISYNC pins (DTI1, DTI2, and EMODE respectively).
- 11. The VOLTDET pin position on the MPC750 360-CBGA package is now an L2OVDD pin on the MPC7400 360-CBGA package.
- 12. Output only for MPC7400, was I/O for MPC750.
- 13. Enhanced mode only.

# 1.7 Package Description

The following sections provide the package parameters and mechanical dimensions for the MPC7400, 360 CBGA packages.

### 1.7.1 Package Parameters for the MPC7400

The package parameters are as provided in the following list. The package type is 25 x 25 mm, 360-lead ceramic ball grid array (CBGA).

Package outline 25 x 25 mm

Interconnects 360 (19 x 19 ball array - 1)

Pitch 1.27 mm (50 mil)

Minimum module height 2.65 mm Maximum module height 3.20 mm

Ball diameter 0.89 mm (35 mil)



### 1.7.2 Mechanical Dimensions of the MPC7400

Figure 17 provides the mechanical dimensions and bottom surface nomenclature of the MPC7400, 360 CBGA package.

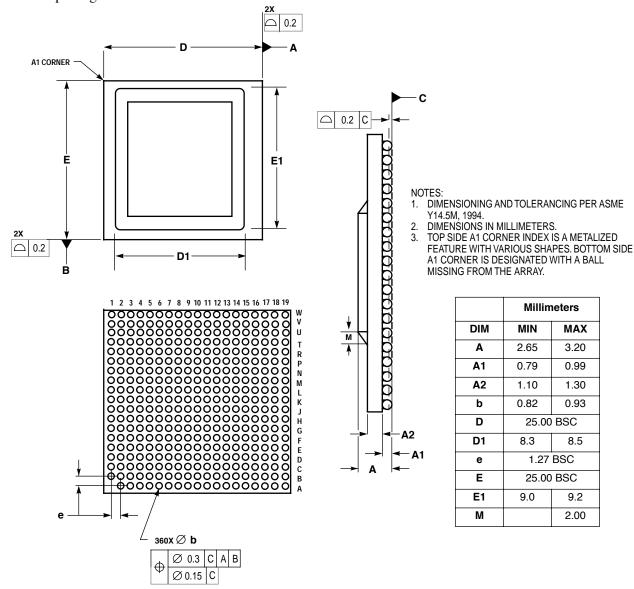


Figure 17. Mechanical Dimensions and Bottom Surface Nomenclature of the MPC7400

# 1.8 System Design Information

This section provides electrical and thermal design recommendations for successful application of the MPC7400.

### 1.8.1 PLL Configuration

The MPC7400's PLL is configured by the PLL\_CFG[0-3] signals. For a given SYSCLK (bus) frequency, the PLL configuration signals set the internal CPU and VCO frequency of operation. The PLL configuration for the MPC7400 is shown in Table 14 for example frequencies.

Table 14. MPC7400 Microprocessor PLL Configuration

		Examp	le Bus-to-	Core Fre	equency in	MHz (VC	O Frequen	cy in MHz)	)	
PLL_CFG [0-3]	Bus-to- Core Multiplier	Core-to VCO Multiplier	Bus 25 MHz	Bus 33.3 MHz	Bus 50 MHz	Bus 66.6 MHz	Bus 75 MHz	Bus 100 MHz	Bus 133 MHz	Bus 150 MHz
0100	2x	2x						200 (400)	266 (533)	300 (600)
0110	2.5x	2x					187 (375)	250 (500)	333 (666)	375 (750)
1000	3x	2x				200 (400)	225 (450)	300 (600)	400 (800)	450 (900)
1110	3.5x	2x			175 (350)	233 (466)	262 (525)	350 (700)		
1010	4x	2x			200 (400)	266 (533)	300 (600)	400 (800)		
0111	4.5x	2x			225 (450)	300 (600)	337 (675)	450 (900)		
1011	5x	2x			250 (500)	333 (666)	375 (750)			
1001	5.5x	2x		183 (366)	275 (550)	366 (733)	412 (825)			
1101	6x	2x		200 (400)	300 (600)	400 (800)	450 (900)			
0101	6.5x	2x		216 (433)	325 (630)	433 (866)				
0010	7x	2x	175 (350)	233 (466)	350 (700)					
0001	7.5x	2x	187 (375)	250 (500)	375 (750)					
1100	8x	2x	200 (400)	266 (533)	400 (800)					
0000	9x	2x	225 (450)	300 (600)	450 (900)					
0011	PLL of	f/bypass	PLL	off, SYS	CLK clocks	core circu	uitry directly	, 1x bus-to-	core imp	lied
1111	PL	L off			PLL o	ff, no core	clocking o	ccurs		

#### Notes:

- 1. PLL\_CFG[0-3] settings not listed are reserved.
- 2. The sample bus-to-core frequencies shown are for reference only. Some PLL configurations may select bus, core, or VCO frequencies which are not useful, not supported, or not tested for by the MPC7400; see Section 1.4.2.1, "Clock AC Specifications," for valid SYSCLK, core, and VCO frequencies.
- 3. In PLL-bypass mode, the SYSCLK input signal clocks the internal processor directly, the PLL is disabled, and the bus mode is set for 1:1 mode operation. This mode is intended for factory use only.

  Note: The AC timing specifications given in this document do not apply in PLL-bypass mode.
- 4. In PLL-off mode, no clocking occurs inside the MPC7400 regardless of the SYSCLK input.

The MPC7400 generates the clock for the external L2 synchronous data SRAMs by dividing the core clock frequency of the MPC7400. The divided-down clock is then phase-adjusted by an on-chip delay-lock-loop (DLL) circuit and should be routed from the MPC7400 to the external RAMs. A separate clock output, L2SYNC\_OUT is sent out half the distance to the SRAMs and then returned as an input to the DLL on pin L2SYNC\_IN so that the rising-edge of the clock as seen at the external RAMs can be aligned to the clocking of the internal latches in the L2 bus interface.

The core-to-L2 frequency divisor for the L2 PLL is selected through the L2CLK bits of the L2CR register. Generally, the divisor must be chosen according to the frequency supported by the external RAMs, the frequency of the MPC7400 core, and the phase adjustment range that the L2 DLL supports. Table 15 shows various example L2 clock frequencies that can be obtained for a given set of core frequencies. The minimum L2 frequency target is 100MHz.

Core Frequency in MHz	÷1	÷1.5	÷2	÷2.5	÷3	÷3.5	÷4
200	200	133.3	100	_	-	-	_
225	225	150	112.5	_	_	_	_
250	_	166	125	100	_	_	_
266	_	177.3	133	106.4	ı	ı	_
300	_	200	150	120	100	_	_
333	_	222	166	133	111	_	_
350	_	_	175	140	117	100	_
366	_	_	183	147	122	105	_
400	_	_	200	160	133	114	100

Table 15. Sample Core-to-L2 Frequencies

### Note:

### 1.8.2 PLL Power Supply Filtering

The AVdd and L2AVdd power signals are provided on the MPC7400 to provide power to the clock generation phase-locked loop and L2 cache delay-locked loop respectively. To ensure stability of the internal clock, the power supplied to the AVdd input signal should be filtered of any noise in the 500kHz to 10MHz resonant frequency range of the PLL. A circuit similar to the one shown in Figure 18 using surface mount capacitors with minimum Effective Series Inductance (ESL) is recommended.

The circuit should be placed as close as possible to the AVdd pin to minimize noise coupled from nearby circuits. An identical but separate circuit should be placed as close as possible to the L2AVdd pin. It is often possible to route directly from the capacitors to the AVdd pin, which is on the periphery of the 360 CBGA footprint, without the inductance of vias. The L2AVdd pin may be more difficult to route but is proportionately less critical.

<sup>1.</sup> The core and L2 frequencies are for reference only. Some examples may represent core or L2 frequencies which are not useful, not supported, or not tested for by the MPC7400; see Section 1.4.2.3, "L2 Clock AC Specifications," for valid L2CLK frequencies. The L2CR[L2SL] bit should be set for L2CLK frequencies less than 110 MHz.

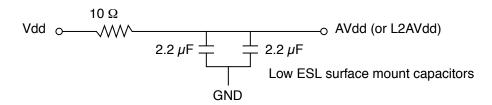


Figure 18. PLL Power Supply Filter Circuit

### 1.8.3 Power Supply Voltage Sequencing

The notes in Table 1 contain cautions about the sequencing of the external bus voltages and core voltage of the MPC7400 (when they are different). These cautions are necessary for the long term reliability of the part. If they are violated, the ESD (Electrostatic Discharge) protection diodes will be forward biased and excessive current can flow through these diodes. If the system power supply design does not control the voltage sequencing, one or both of the circuits of Figure 19 can be added to meet these requirements. The MUR420 Schottky diodes of Figure 19 control the maximum potential difference between the external bus and core power supplies on power-up and the 1N5820 diodes regulate the maximum potential difference on power-down.

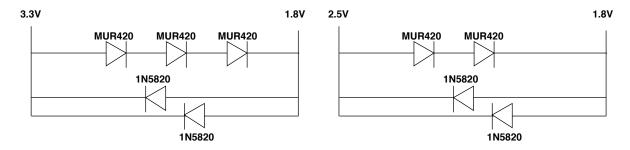


Figure 19. Example Voltage Sequencing Circuits

### 1.8.4 Decoupling Recommendations

Due to the MPC7400's dynamic power management feature, large address and data buses, and high operating frequencies, the MPC7400 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 MPC7400 system, and the MPC7400 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 Vdd, OVdd, and L2OVdd pin of the MPC7400. It is also recommended that these decoupling capacitors receive their power from separate Vdd, (L2)OVdd, and GND power planes in the PCB, utilizing short traces to minimize inductance.

These capacitors should have a value of  $0.01~\mu\text{F}$  or  $0.1~\mu\text{F}$ . Only ceramic SMT (surface mount technology) capacitors should be used to minimize lead inductance, preferably 0508 or 0603 orientations where connections are made along the length of the part. Consistent with the recommendations of Dr. Howard Johnson in <u>High Speed Digital Design: A Handbook of Black Magic</u> (Prentice Hall, 1993) and contrary to previous recommendations for decoupling PowerPC microprocessors, multiple small capacitors of equal value are recommended over using multiple values of capacitance.

In addition, it is recommended that there be several bulk storage capacitors distributed around the PCB, feeding the Vdd, L2OVdd, and OVdd 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— $100-330 \mu F$  (AVX TPS tantalum or Sanyo OSCON).

### 1.8.5 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 OVdd. 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 Vdd, OVdd, L2OVdd, and GND pins of the MPC7400.

See Section 1.4.2.3, "L2 Clock AC Specifications" for a discussion of the L2SYNC\_OUT and L2SYNC\_IN signals.

### 1.8.6 Output Buffer DC Impedance

The MPC7400 60x and L2 I/O drivers are characterized over process, voltage, and temperature. To measure  $Z_0$ , an external resistor is connected from the chip pad to OVdd or GND. Then, the value of each resistor is varied until the pad voltage is OVdd/2 (see Figure 20).

The output impedance is the average of two components, the resistances of the pull-up and pull-down devices. When Data is held low, SW2 is closed (SW1 is open), and  $R_N$  is trimmed until the voltage at the pad equals OVdd/2.  $R_N$  then becomes the resistance of the 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 OVdd/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  $Z_0 = (R_P + R_N)/2$ .

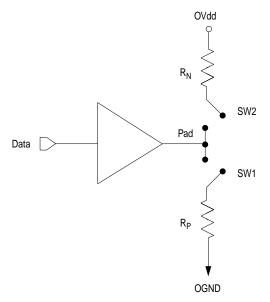


Figure 20. Driver Impedance Measurement

Table 16 summarizes the signal impedance results. The driver impedance values were characterized at 0°C, 65 °C, and 105 °C. The impedance increases with junction temperature and is relatively unaffected by bus voltage.

**Table 16. Impedance Characteristics** 

Vdd = 1.8V, OVdd = 3.3V, Tj = 0 - 105 °C

Impedance	Processor bus	L2 bus	Symbol	Unit
R <sub>N</sub>	32-43	39-48	Z <sub>0</sub>	Ohms
R <sub>P</sub>	36-48	41-50	Z <sub>0</sub>	Ohms

### 1.8.7 Pull-up Resistor Requirements

The MPC7400 requires high-resistive (weak:  $10~\text{K}\Omega$ ) pull-up resistors on several control pins of the bus interface to maintain the control signals in the negated state after they have been actively negated and released by the MPC7400 or other bus masters. These pins are  $\overline{\text{TS}}$ ,  $\overline{\text{ARTRY}}$ ,  $\overline{\text{SHDO}}$ , and  $\overline{\text{SHD1}}$ .

In addition, the MPC7400 has one open-drain style output that requires a pull-up resistor (weak or stronger: 4.7 K $\Omega$ –10 K $\Omega$ ) if it is used by the system. This pin is CKSTP\_OUT.

During inactive periods on the bus, the address and transfer attributes may not be driven by any master and may therefore float in the high-impedance state for relatively long periods of time. Since the MPC7400 must continually monitor these signals for snooping, this float condition may cause excessive power draw by the input receivers on the MPC7400 or by other receivers in the system. It is recommended that these signals be pulled up through weak (10  $K\Omega$ ) pull-up resistors by the system, or that they may be otherwise driven by the system during inactive periods of the bus. The snooped address and transfer attribute inputs are: A[0:31], AP[0:3], TT[0:4], and  $\overline{GBL}$ .

The data bus input receivers are normally turned off when no read operation is in progress and therefore do not require pull-up resistors on the bus. Other data bus receivers in the system, however, may require pullups, or that those signals be otherwise driven by the system during inactive periods by the system. The data bus signals are: D[0:63], DP[0:7]

If address or data parity is not used by the system, and the respective parity *checking* is disabled through HID0, the input receivers for those pins are disabled, and those pins do not require pull-up resistors and should be left unconnected by the system. If all parity *generation* is disabled through HID0, then all parity *checking* should also be disabled through HID0, and all parity pins may be left unconnected by the system.

The L2 interface does not normally require pull-up resistors.

### 1.8.8 JTAG Configuration Signals

Boundary scan testing is enabled through the JTAG interface signals. (BSDL descriptions of the MPC7400 are available on the internet at www.mot.com/PowerPC/teksupport.) The  $\overline{TRST}$  signal is optional in the IEEE 1149.1 specification but is provided on all PowerPC implementations. While it is possible to force the TAP controller to the reset state using only the TCK and TMS signals, more reliable power-on reset performance will be obtained if the  $\overline{TRST}$  signal is asserted during power-on reset. Since the JTAG interface is also used for accessing the common on-chip processor (COP) function of PowerPC processors, simply tying  $\overline{TRST}$  to  $\overline{HRESET}$  isn't practical.

The common on-chip processor (COP) function of PowerPC processors allows a remote computer system (typically a PC with dedicated hardware and debugging software) to access and control the internal operations of the processor. The COP interface connects primarily through the JTAG port of the processor, with some additional status monitoring signals. The COP port requires the ability to independently assert **HRESET** or **TRST** in order to fully control the processor. If the target system has independent reset sources, such as voltage monitors, watchdog timers, power supply failures, or push-button switches, then the COP reset signals must be merged into these signals with logic.

The arrangement shown in Figure 21 allows the COP to independently assert **TRST**, while insuring that the target can drive **TRST** as well. The pull-down resistor on **TRST** ensures that the JTAG scan chain is initialized during power-on if a JTAG interface cable is not attached; if it is, it is responsible for driving **TRST** when needed.

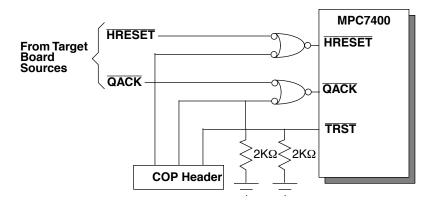


Figure 21. Suggested TRST connection

The COP header shown in Figure 21 adds many benefits—breakpoints, watchpoints, register and memory examination/modification and other standard debugger features are possible through this interface – and can be as inexpensive as an unpopulated footprint for a header to be added when needed.

The COP interface has a standard header for connection to the target system, based on the 0.025" square-post 0.100" centered header assembly (often called a "Berg" header). The connector typically has pin 14 removed as a connector key, as shown in Figure 22.

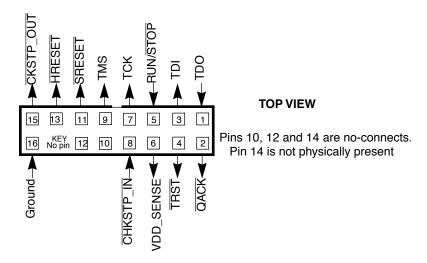


Figure 22. COP Connector Diagram

There is no standardized way to number the COP header shown in Figure 22; consequently, many different pin numbers have been observed from emulator vendors. Some are numbered top-to-bottom then left-to-right, while others use left-to-right then top-to-bottom, while still others number the pins counter clockwise from pin one (as with an IC). Regardless of the numbering, the signal placement recommended in Figure 22 is common to all known emulators.

The  $\overline{QACK}$  signal shown in Table 17 is usually hooked up to the PCI bridge chip in a system and is an input to the MPC7400 informing it that it can go into the quiescent state. Under normal operation this occurs

### **System Design Information**

during a low power mode selection. In order for COP to work the MPC7400 must see this signal asserted (pulled down). While shown on the COP header, not all emulator products drive this signal. To preserve correct power down operation, QACK should be merged so that it also can be driven by the PCI bridge.

Table 17 shows the pin definitions.

**Table 17. COP Pin Definitions** 

Pins	Signal	Connection	Special Notes
1	TDO	TDO	
2	QACK	QACK	Add 2K pulldown to ground. Must be merged with on-board <b>QACK</b> , if any.
3	TDI	TDI	
4	TRST	TRST	Add 2K pulldown to ground. Must be merged with on-board <b>TRST</b> , if any. See Figure 21
5	RUN/STOP	No Connect	Used on 604e; leave no-connect for all other processors.
6	VDD_SENSE	VDD	Add 2K pullup to OVDD (for short circuit limiting protection only).
7	тск	тск	
8	CKSTP_IN	CKSTP_IN	Optional. Add 10K pullup to VDD. Used on several emulator products. Useful for checkstopping the processor from a logic analyzer of other external trigger.
9	TMS	TMS	
10	N/A		
11	SRESET	SRESET	Merge with on-board SRESET, if any.
12	N/A		
13	HRESET	HRESET	Merge with on-board HRESET.
14	N/A		Key location; pin should be removed.
15	CKSTP_OUT	CKSTP_OUT	Add 10K pullup to VDD.
16	Ground	Digital Ground	

### 1.8.9 Thermal Management Information

This section provides thermal management information for the ceramic ball grid array (CBGA) package for air-cooled applications. Proper thermal control design is primarily dependent upon 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—adhesive, spring clip to holes in the printed-circuit board or package, and mounting clip and screw assembly; see Figure 23. This spring force should not exceed 5.5 pounds of force.

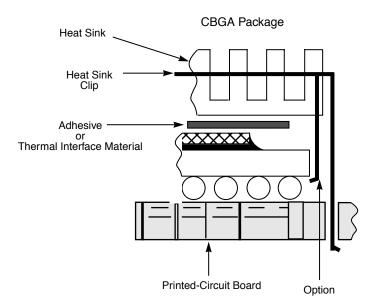


Figure 23. Package Exploded Cross-Sectional View with Several Heat Sink Options

The board designer can choose between several types of heat sinks to place on the MPC7400. There are several commercially-available heat sinks for the MPC7400 provided by the following vendors:

Chip Coolers Inc. 333 Strawberry Field Rd. Warwick, RI 02887-6979	800-227-0254 (USA/Canada) 401-739-7600
International Electronic Research Corporation (IERC) 135 W. Magnolia Blvd. Burbank, CA 91502	818-842-7277
Thermalloy 2021 W. Valley View Lane P.O. Box 810839 Dallas, TX 75731	214-243-4321
Wakefield Engineering 60 Audubon Rd. Wakefield, MA 01880	617-245-5900
Aavid Engineering One Kool Path Laconia, NH 03247-0440	603-528-3400

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.

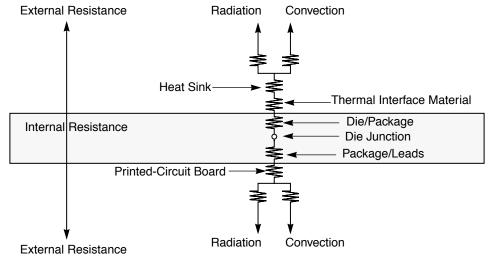
### 1.8.9.1 Internal Package Conduction Resistance

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

- The die junction-to-case (or top-of-die for exposed silicon) thermal resistance
- The die junction-to-ball thermal resistance

### **System Design Information**

Figure 24 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 24. C4 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.

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

### 1.8.9.2 Adhesives and 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 25 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 7 times greater than the thermal grease joint.

Heat sinks are attached to the package by means of a spring clip to holes in the printed-circuit board (see Figure 24). This spring force should not exceed 10 pounds of force. Therefore, the synthetic grease offers the best thermal performance, considering the low interface pressure. Of course, the selection of any thermal interface material depends on many factors—thermal performance requirements, manufacturability, service temperature, dielectric properties, cost, etc.

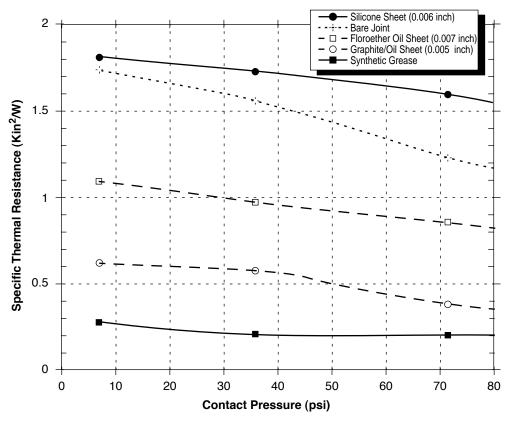


Figure 25. Thermal Performance of Select Thermal Interface Material

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:

Dow-Corning Corporation Dow-Corning Electronic Materials PO Box 0997 Midland, MI 48686-0997	517-496-4000
Chomerics, Inc. 77 Dragon Court Woburn, MA 01888-4850	617-935-4850
Thermagon Inc. 3256 West 25th Street Cleveland, OH 44109-1668	216-741-7659
Loctite Corporation 1001 Trout Brook Crossing Rocky Hill, CT 06067	860-571-5100
AI Technology (e.g. EG7655) 1425 Lower Ferry Rd. Trent, NJ 08618	609-882-2332

### **System Design Information**

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

### 1.8.9.3 Heat Sink Selection Example

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

$$T_i = T_a + T_r + (\theta_{ic} + \theta_{int} + \theta_{sa}) * P_d$$

Where:

T<sub>i</sub> is the die-junction temperature

T<sub>a</sub> is the inlet cabinet ambient temperature

 $T_r$  is the air temperature rise within the computer cabinet

 $\theta_{ic}$  is the junction-to-case thermal resistance

 $\theta_{int}$  is the adhesive or interface material thermal resistance

 $\theta_{sa}$  is the heat sink base-to-ambient thermal resistance

P<sub>d</sub> is the power dissipated by the device

During operation the die-junction temperatures  $(T_j)$  should be maintained less than the value specified in Table 3. The temperature of the air cooling the component greatly depends upon the ambient inlet air temperature and the air temperature rise within the electronic cabinet. An electronic cabinet inlet-air temperature  $(T_a)$  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  $(\theta_{int})$  is typically about 1 °C/W. Assuming a  $T_a$  of 30 °C, a  $T_r$  of 5 °C, a CBGA package  $\theta_{jc} = 0.03$ , and a power consumption  $(P_d)$  of 5.0 watts, the following expression for  $T_i$  is obtained:

Die-junction temperature: 
$$T_i = 30 \, ^{\circ}\text{C} + 5 \, ^{\circ}\text{C} + (0.03 \, ^{\circ}\text{C/W} + 1.0 \, ^{\circ}\text{C/W} + \theta_{sa}) \, ^{*} \, 5.0 \, \text{W}$$

For a Thermalloy heat sink #2328B, the heat sink-to-ambient thermal resistance ( $\theta_{sa}$ ) versus airflow velocity is shown in Figure 26.

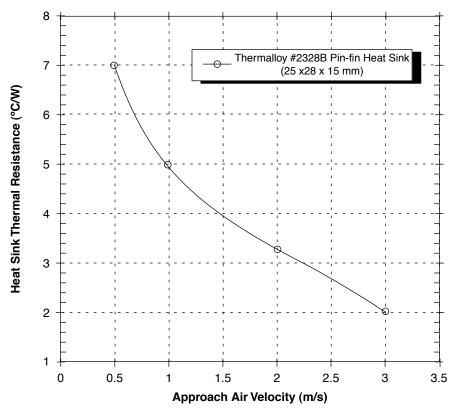


Figure 26. Thermalloy #2328B Heat Sink-to-Ambient Thermal Resistance Versus Airflow Velocity

Assuming an air velocity of 0.5 m/s, we have an effective R<sub>sa</sub> of 7 °C/W, thus  $T_i = 30 \, ^{\circ}\text{C} + 5 \, ^{\circ}\text{C} + (0.03 \, ^{\circ}\text{C/W} + 1.0 \, ^{\circ}\text{C/W} + 7 \, ^{\circ}\text{C/W}) * 5.0 \, \text{W},$ 

resulting in a die-junction temperature of approximately 75 °C which is well within the maximum operating temperature of the component.

Other heat sinks offered by Chip Coolers, IERC, Thermalloy, Wakefield Engineering, and Aavid Engineering offer different heat sink-to-ambient thermal resistances, and may or may not need air flow.

Though the die junction-to-ambient and the heat sink-to-ambient thermal resistances are a common figureof-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.

Due to the complexity and the many variations of system-level boundary conditions for today's microelectronic equipment, the combined effects of the heat transfer mechanisms (radiation, convection and conduction) may vary widely. For these reasons, we recommend using conjugate heat transfer models for the board, as well as, system-level designs. To expedite system-level thermal analysis, several "compact" thermal-package models are available within FLOTHERM®. These are available upon request.

# 1.9 Document Revision History

Table 18 provides a revision history for this hardware specification.

**Table 18. Document Revision History** 

Document Revision	Substantive Change(s)
Rev 0	Initial release

# 1.10 Ordering Information

Figure 27 provides the Motorola part numbering nomenclature for the MPC7400. 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 consists of a part modifier and application modifier. The part modifier indicates any enhancement(s) in the part from the original production design. The bus divider may specify special bus frequencies or application conditions. Each part number also contains a revision code. This refers to the die mask revision number and is specified in the part numbering scheme for identification purposes only.

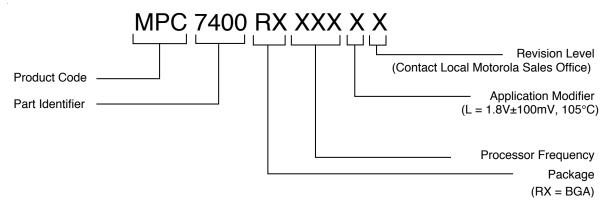


Figure 27. Motorola Part Number Key

Mfax is a trademark of Motorola, Inc.

The PowerPC name, the PowerPC logotype, and PowerPC 603e are trademarks of International Business Machines Corporation used by Motorola under license from International Business Machines Corporation.

Information in this document is provided solely to enable system and software implementers to use PowerPC microprocessors. There are no express or implied copyright licenses granted hereunder to design or fabricate PowerPC integrated circuits or integrated circuits based on the information in this document.

Motorola reserves the right to make changes without further notice to any products herein. Motorola makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Motorola assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters can and do vary in different applications. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Motorola does not convey any license under its patent rights nor the rights of others. Motorola products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Motorola product could create a situation where personal injury or death may occur. Should Buyer purchase or use Motorola products for any such unintended or unauthorized application, Buyer shall indemnify and hold Motorola and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Motorola was negligent regarding the design or manufacture of the part.

Motorola and (M) are registered trademarks of Motorola, Inc. Motorola, Inc. is an Equal Opportunity/Affirmative Action Employer.

#### **Motorola Literature Distribution Centers:**

**USA/EUROPE:** Motorola Literature Distribution; P.O. Box 5405; Denver, Colorado 80217; Tel.: 1-800-441-2447 or 1-303-675-2140; World Wide Web Address: http://ldc.nmd.com/

JAPAN: Nippon Motorola Ltd SPD, Strategic Planning Office 4-32-1, Nishi-Gotanda Shinagawa-ku, Tokyo 141, Japan Tel.: 81-3-5487-8488

ASIA/PACIFIC: Motorola Semiconductors H.K. Ltd Silicon Harbour Centre 2, Dai King Street Tai Po Industrial Estate Tai Po, New Territories, Hong Kong

Mfax™: RMFAX0@email.sps.mot.com; TOUCHTONE 1-602-244-6609; US & Canada ONLY (800) 774-1848;

World Wide Web Address: http://sps.motorola.com/mfax

INTERNET: http://motorola.com/sps

Technical Information: Motorola Inc. SPS Customer Support Center 1-800-521-6274; electronic mail address: crc@wmkmail.sps.mot.com.

Document Comments: FAX (512) 895-2638, Attn: RISC Applications Engineering.

World Wide Web Addresses: http://www.motorola.com/PowerPC

http://www.motorola.com/netcomm http://www.motorola.com/Coldfire

