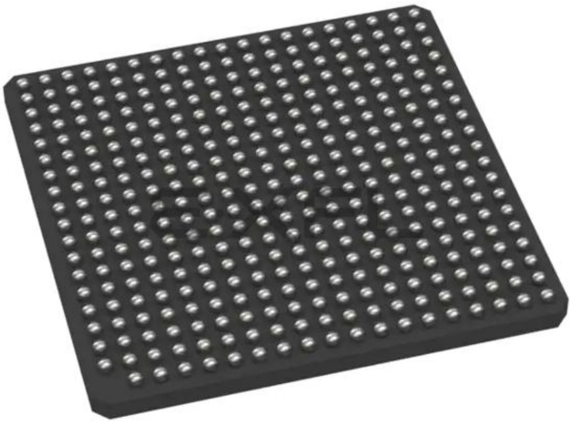


Welcome to E-XFL.COM

Understanding Embedded - Microprocessors

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

Applications of Embedded - Microprocessors

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

Details	
Product Status	Obsolete
Core Processor	PowerPC G4
Number of Cores/Bus Width	1 Core, 32-Bit
Speed	1.42GHz
Co-Processors/DSP	Multimedia; SIMD
RAM Controllers	-
Graphics Acceleration	No
Display & Interface Controllers	-
Ethernet	-
SATA	-
USB	-
Voltage - I/O	1.5V, 1.8V, 2.5V
Operating Temperature	0°C ~ 105°C (TA)
Security Features	-
Package / Case	360-BCBGA, FCCBGA
Supplier Device Package	360-FCCBGA (25x25)
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/mc7448hx1420ld

2 Features

This section summarizes features of the MPC7448 implementation.

Major features of the MPC7448 are as follows:

- High-performance, superscalar microprocessor
  - Up to four instructions can be fetched from the instruction cache at a time.
  - Up to three instructions plus a branch instruction can be dispatched to the issue queues at a time.
  - Up to 12 instructions can be in the instruction queue (IQ).
  - Up to 16 instructions can be at some stage of execution simultaneously.
  - Single-cycle execution for most instructions
  - One instruction per clock cycle throughput for most instructions
  - Seven-stage pipeline control
- Eleven independent execution units and three register files
  - Branch processing unit (BPU) features static and dynamic branch prediction
    - 128-entry (32-set, four-way set-associative) branch target instruction cache (BTIC), a cache of branch instructions that have been encountered in branch/loop code sequences. If a target instruction is in the BTIC, it is fetched into the instruction queue a cycle sooner than it can be made available from the instruction cache. Typically, a fetch that hits the BTIC provides the first four instructions in the target stream.
    - 2048-entry branch history table (BHT) with 2 bits per entry for four levels of prediction—not taken, strongly not taken, taken, and strongly taken
    - Up to three outstanding speculative branches
    - Branch instructions that do not update the count register (CTR) or link register (LR) are often removed from the instruction stream.
    - Eight-entry link register stack to predict the target address of Branch Conditional to Link Register (**bclr**) instructions
  - Four integer units (IUs) that share 32 GPRs for integer operands
    - Three identical IUs (IU1a, IU1b, and IU1c) can execute all integer instructions except multiply, divide, and move to/from special-purpose register instructions.
    - IU2 executes miscellaneous instructions, including the CR logical operations, integer multiplication and division instructions, and move to/from special-purpose register instructions.
  - Five-stage FPU and 32-entry FPR file
    - Fully IEEE Std. 754™-1985–compliant FPU for both single- and double-precision operations
    - Supports non-IEEE mode for time-critical operations
    - Hardware support for denormalized numbers
    - Thirty-two 64-bit FPRs for single- or double-precision operands

- — Monitors all dispatched instructions and retires them in order
- — Tracks unresolved branches and flushes instructions after a mispredicted branch
- — Retires as many as three instructions per clock cycle

- Separate on-chip L1 instruction and data caches (Harvard architecture)
  - — 32-Kbyte, eight-way set-associative instruction and data caches
  - — Pseudo least-recently-used (PLRU) replacement algorithm
  - — 32-byte (eight-word) L1 cache block
  - — Physically indexed/physical tags
  - — Cache write-back or write-through operation programmable on a per-page or per-block basis
  - — Instruction cache can provide four instructions per clock cycle; data cache can provide four words per clock cycle
  - — Caches can be disabled in software.
  - — Caches can be locked in software.
  - — MESI data cache coherency maintained in hardware
  - — Separate copy of data cache tags for efficient snooping
  - — Parity support on cache
  - — No snooping of instruction cache except for **icbi** instruction
  - — Data cache supports AltiVec LRU and transient instructions
  - — Critical double- and/or quad-word forwarding is performed as needed. Critical quad-word forwarding is used for AltiVec loads and instruction fetches. Other accesses use critical double-word forwarding.
- Level 2 (L2) cache interface
  - — On-chip, 1-Mbyte, eight-way set-associative unified instruction and data cache
  - — Cache write-back or write-through operation programmable on a per-page or per-block basis
  - — Parity support on cache tags
  - — ECC or parity support on data
  - — Error injection allows testing of error recovery software
- Separate memory management units (MMUs) for instructions and data
  - — 52-bit virtual address, 32- or 36-bit physical address
  - — Address translation for 4-Kbyte pages, variable-sized blocks, and 256-Mbyte segments
  - — Memory programmable as write-back/write-through, caching-inhibited/caching-allowed, and memory coherency enforced/memory coherency not enforced on a page or block basis
  - — Separate IBATs and DBATs (eight each) also defined as SPRs
  - — Separate instruction and data translation lookaside buffers (TLBs)
    - – Both TLBs are 128-entry, two-way set-associative and use an LRU replacement algorithm.
    - – TLBs are hardware- or software-reloadable (that is, a page table search is performed in hardware or by system software on a TLB miss).

- Efficient data flow
  - — Although the VR/LSU interface is 128 bits, the L1/L2 bus interface allows up to 256 bits.
  - — The L1 data cache is fully pipelined to provide 128 bits/cycle to or from the VRs.
  - — The L2 cache is fully pipelined to provide 32 bytes per clock every other cycle to the L1 caches.
  - — As many as 16 out-of-order transactions can be present on the MPX bus.
  - — Store merging for multiple store misses to the same line. Only coherency action taken (address-only) for store misses merged to all 32 bytes of a cache block (no data tenure needed).
  - — Three-entry finished store queue and five-entry completed store queue between the LSU and the L1 data cache
  - — Separate additional queues for efficient buffering of outbound data (such as castouts and write-through stores) from the L1 data cache and L2 cache
- Multiprocessing support features include the following:
  - — Hardware-enforced, MESI cache coherency protocols for data cache
  - — Load/store with reservation instruction pair for atomic memory references, semaphores, and other multiprocessor operations
- Power and thermal management
  - — Dynamic frequency switching (DFS) feature allows processor core frequency to be halved or quartered through software to reduce power consumption.
  - — The following three power-saving modes are available to the system:
    - – Nap—Instruction fetching is halted. Only the clocks for the time base, decrementer, and JTAG logic remain running. The part goes into the doze state to snoop memory operations on the bus and then back to nap using a $\overline{\text{QREQ}}$/$\overline{\text{QACK}}$ processor-system handshake protocol.
    - – Sleep—Power consumption is further reduced by disabling bus snooping, leaving only the PLL in a locked and running state. All internal functional units are disabled.
    - – Deep sleep—When the part is in the sleep state, the system can disable the PLL. The system can then disable the SYSCLK source for greater system power savings. Power-on reset procedures for restarting and relocking the PLL must be followed upon exiting the deep sleep state.
  - — Instruction cache throttling provides control of instruction fetching to limit device temperature.
  - — A new temperature diode that can determine the temperature of the microprocessor
- Performance monitor can be used to help debug system designs and improve software efficiency.
- In-system testability and debugging features through JTAG boundary-scan capability
- Testability
  - — LSSD scan design
  - — IEEE Std. 1149.1™ JTAG interface

Figure 2 shows the undershoot and overshoot voltage on the MPC7448.

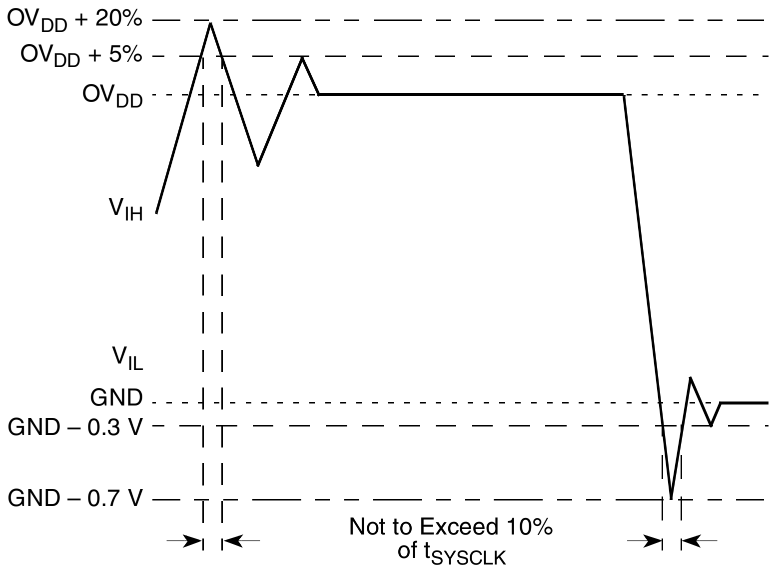


Figure 2. Overshoot/Undershoot Voltage

The MPC7448 provides several I/O voltages to support both compatibility with existing systems and migration to future systems. The MPC7448 core voltage must always be provided at the nominal voltage (see Table 4). 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 OV_{DD} power pins. Table 3 provides the input threshold voltage settings. Because these settings may change in future products, it is recommended that BVSEL[0:1] be configured using resistor options, jumpers, or some other flexible means, with the capability to reconfigure the termination of this signal in the future, if necessary.

Table 3. Input Threshold Voltage Setting

BVSEL0	BVSEL1	I/O Voltage Mode[1]	Notes
0	0	1.8 V	2, 3
0	1	2.5 V	2, 4
1	0	1.5 V	2
1	1	2.5 V	4

Notes:

1. **Caution:** The I/O voltage mode selected must agree with the OV_{DD} voltages supplied. See Table 4.
2. If used, pull-down resistors should be less than 250 Ω.
3. The pin configuration used to select 1.8V mode on the MPC7448 is not compatible with the pin configuration used to select 1.8V mode on the MPC7447A and earlier devices.
4. The pin configuration used to select 2.5V mode on the MPC7448 is fully compatible with the pin configuration used to select 2.5V mode on the MPC7447A and earlier devices.

Table 8. Clock AC Timing Specifications

At recommended operating conditions. See Table 4.

Characteristic		Symbol	Maximum Processor Core Frequency (Speed Grade)								Unit	Notes
			1000 MHz		1420 MHz		1600 MHz		1700 MHz			
			Min	Max	Min	Max	Min	Max	Min	Max		
Processor core frequency	DFS mode disabled	f_{core}	600	1000	600	1420	600	1600	600	1700	MHz	1, 8
	DFS mode enabled	$f_{core–DF}$	300	500	300	710	300	800	300	850		9
VCO frequency		f_{VCO}	600	1000	600	1420	600	800	600	1700	MHz	1, 10
SYSCLK frequency		f_{SYSCLK}	33	200	33	200	33	200	33	200	MHz	1, 2, 8
SYSCLK cycle time		t_{SYSCLK}	5.0	30	5.0	30	5.0	30	5.0	30	ns	2
SYSCLK rise and fall time		t_{KR}, t_{KF}	—	0.5	—	0.5	—	0.5	—	0.5	ns	3
SYSCLK duty cycle measured at $OV_{DD}/2$		t_{KHKL}/t_{SYSCLK}	40	60	40	60	40	60	40	60	%	4
SYSCLK cycle-to-cycle jitter			—	150	—	150	—	150	—	150	ps	5, 6
Internal PLL relock time			—	100	—	100	—	100	—	100	µs	7

Notes:

1. **Caution**: The SYSCLK frequency and PLL_CFG[0:5] settings must be chosen such that the resulting SYSCLK (bus) frequency, processor core frequency, and PLL (VCO) frequency do not exceed their respective maximum or minimum operating frequencies. Refer to the PLL_CFG[0:5] signal description in Section 9.1.1, "PLL Configuration," for valid PLL_CFG[0:5] settings.
2. Actual maximum system bus frequency is system-dependent. See Section 5.2.1, "Clock AC Specifications."
3. Rise and fall times for the SYSCLK input measured from 0.4 to 1.4 V
4. Timing is guaranteed by design and characterization.
5. Guaranteed by design
6. The SYSCLK driver's closed loop jitter bandwidth should be less than 1.5 MHz at –3 dB.
7. Relock timing is guaranteed by design and characterization. PLL-relock time is the maximum amount of time required for PLL lock after a stable V_{DD} 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 $\overline{HRESET}$ must be held asserted for a minimum of 255 bus clocks after the PLL-relock time during the power-on reset sequence.
8. This reflects the maximum and minimum core frequencies when the dynamic frequency switching feature (DFS) is disabled. f_{core_DFS} provides the maximum and minimum core frequencies when operating in a DFS mode.
9. This specification supports the Dynamic Frequency Switching (DFS) feature and is applicable only when one of the DFS modes (divide-by-2 or divide-by-4) is enabled. When DFS is disabled, the core frequency must conform to the maximum and minimum frequencies stated for f_{core}.
10. Use of the DFS feature does not affect VCO frequency.

Figure 3 provides the SYSCLK input timing diagram.

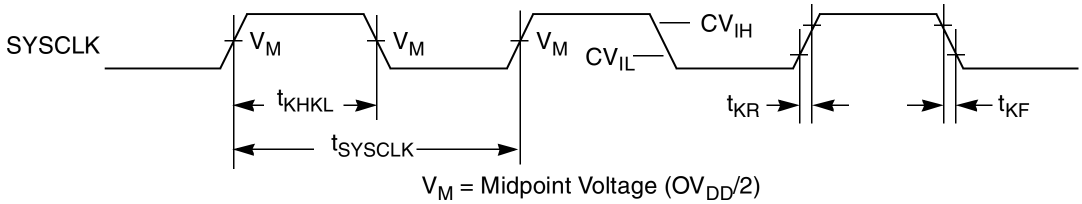


Figure 3. SYSCLK Input Timing Diagram

5.2.2 Processor Bus AC Specifications

Table 9 provides the processor bus AC timing specifications for the MPC7448 as defined in Figure 4 and Figure 5.

Table 9. Processor Bus AC Timing Specifications[1]

At recommended operating conditions. See Table 4.

Parameter	Symbol [2]	All Speed Grades Min	All Speed Grades Max	Unit	Notes
Input setup times:				ns	
A[0:35], AP[0:4]	t_{AVKH}	1.5	—		—
D[0:63], DP[0:7]	t_{DVKH}	1.5	—		—
AACK, ARTRY, BG, CKSTP_IN, DBG, DTI[0:3], GBL, TT[0:4], QACK, TA, TBEN, TEA, TS, EXT_QUAL, PMON_IN, SHD[0:1]	t_{IVKH}	1.5	—		—
BMODE[0:1], BVSEL[0:1]	t_{MVKH}	1.5	—		8
Input hold times:				ns	
A[0:35], AP[0:4]	t_{AXKH}	0	—		—
D[0:63], DP[0:7]	t_{DXKH}	0	—		—
AACK, ARTRY, BG, CKSTP_IN, DBG, DTI[0:3], GBL, TT[0:4], QACK, TA, TBEN, TEA, TS, EXT_QUAL, PMON_IN, SHD[0:1]	t_{IXKH}	0	—		—
					—
BMODE[0:1], BVSEL[0:1]	t_{MXKH}	0	—		8
Output valid times:				ns	
A[0:35], AP[0:4]	t_{KHAV}	—	1.8		
D[0:63], DP[0:7]	t_{KHDV}	—	1.8		
BR, CI, DRDY, GBL, HIT, PMON_OUT, QREQ, TBST, TSIZ[0:2], TT[0:4], WT	t_{KHOV}	—	1.8		
TS	t_{KHTSV}	—	1.8		
ARTRY, SHD[0:1]	t_{KHARV}	—	1.8		
Output hold times:				ns	
A[0:35], AP[0:4]	t_{KHAX}	0.5	—		
D[0:63], DP[0:7]	t_{KHDX}	0.5	—		
BR, CI, DRDY, GBL, HIT, PMON_OUT, QREQ, TBST, TSIZ[0:2], TT[0:4], WT	t_{KHOX}	0.5	—		
TS	t_{KHTSX}	0.5	—		
ARTRY, SHD[0:1]	t_{KHARX}	0.5	—		
SYSCLK to output enable	t_{KHOE}	0.5	—	ns	5

Table 9. Processor Bus AC Timing Specifications[1] (continued)

At recommended operating conditions. See Table 4.

Parameter	Symbol [2]	All Speed Grades		Unit	Notes
		Min	Max		
SYSCLK to output high impedance (all except $\overline{\text{TS}}$, $\overline{\text{ARTRY}}$, $\overline{\text{SHD0}}$, $\overline{\text{SHD1}}$)	t_{KHOZ}	—	1.8	ns	5
SYSCLK to $\overline{\text{TS}}$ high impedance after precharge	t_{KHTSPZ}	—	1	t_{SYSCLK}	3, 4, 5
Maximum delay to $\overline{\text{ARTRY}}$/$\overline{\text{SHD0}}$/$\overline{\text{SHD1}}$ precharge	t_{KHARP}	—	1	t_{SYSCLK}	3, 5, 6, 7
SYSCLK to $\overline{\text{ARTRY}}$/$\overline{\text{SHD0}}$/$\overline{\text{SHD1}}$ high impedance after precharge	t_{KHARPZ}	—	2	t_{SYSCLK}	3, 5, 6, 7

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-Ω 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 $t_{(signal)(state)(reference)(state)}$ for inputs and $t_{(reference)(state)(signal)(state)}$ for outputs. For example, t_{IVKH} 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_{KHOV} 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).
3. t_{sysclk} is the period of the external clock (SYSCLK) in ns. The numbers given in the table must be multiplied by the period of SYSCLK to compute the actual time duration (in ns) of the parameter in question.
4. According to the bus protocol, $\overline{\text{TS}}$ is driven only by the currently active bus master. It is asserted low and precharged high before returning to high impedance, as shown in Figure 6. The nominal precharge width for $\overline{\text{TS}}$ is t_{SYSCLK}, that is, one clock period. Since no master can assert $\overline{\text{TS}}$ on the following clock edge, there is no concern regarding contention with the precharge. Output valid and output hold timing is tested for the signal asserted. Output valid time is tested for precharge.The high-impedance behavior is guaranteed by design.
5. Guaranteed by design and not tested
6. According to the bus protocol, $\overline{\text{ARTRY}}$ can be driven by multiple bus masters through the clock period immediately following $\overline{\text{AACK}}$. Bus contention is not an issue because any master asserting $\overline{\text{ARTRY}}$ will be driving it low. Any master asserting it low in the first clock following $\overline{\text{AACK}}$ will then go to high impedance for a fraction of a cycle, then negated for up to an entire cycle (crossing a bus cycle boundary) before being three-stated again. The nominal precharge width for $\overline{\text{ARTRY}}$ is 1.0 t_{SYSCLK}; that is, it should be high impedance as shown in Figure 6 before the first opportunity for another master to assert $\overline{\text{ARTRY}}$. Output valid and output hold timing is tested for the signal asserted.The high-impedance behavior is guaranteed by design.
7. According to the MPX bus protocol, $\overline{\text{SHD0}}$ and $\overline{\text{SHD1}}$ can be driven by multiple bus masters beginning two cycles after $\overline{\text{TS}}$. Timing is the same as $\overline{\text{ARTRY}}$, that is, the signal is high impedance for a fraction of a cycle, then negated for up to an entire cycle (crossing a bus cycle boundary) before being three-stated again. The nominal precharge width for $\overline{\text{SHD0}}$ and $\overline{\text{SHD1}}$ is 1.0 t_{SYSCLK}. The edges of the precharge vary depending on the programmed ratio of core to bus (PLL configurations).
8. $\overline{\text{BMODE}}$[0:1] and BVSEL[0:1] are mode select inputs. $\overline{\text{BMODE}}$[0:1] are sampled before and after $\overline{\text{HRESET}}$ negation. BVSEL[0:1] are sampled before $\overline{\text{HRESET}}$ negation. These parameters represent the input setup and hold times for each sample. These values are guaranteed by design and not tested. $\overline{\text{BMODE}}$[0:1] must remain stable after the second sample; BVSEL[0:1] must remain stable after the first (and only) sample. See Figure 5 for sample timing.

Figure 7 provides the AC test load for TDO and the boundary-scan outputs of the MPC7448.

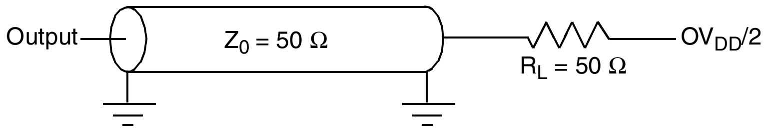


Figure 7. Alternate AC Test Load for the JTAG Interface

Figure 8 provides the JTAG clock input timing diagram.

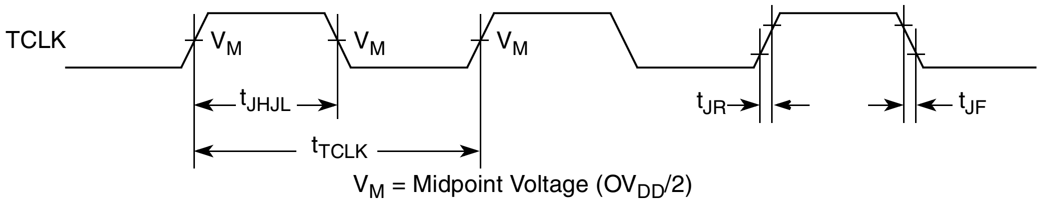


Figure 8. JTAG Clock Input Timing Diagram

Figure 9 provides the $\overline{\text{TRST}}$ timing diagram.

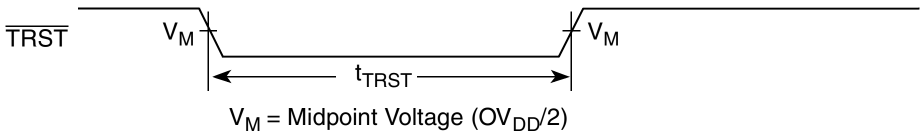


Figure 9. $\overline{\text{TRST}}$ Timing Diagram

Figure 10 provides the boundary-scan timing diagram.

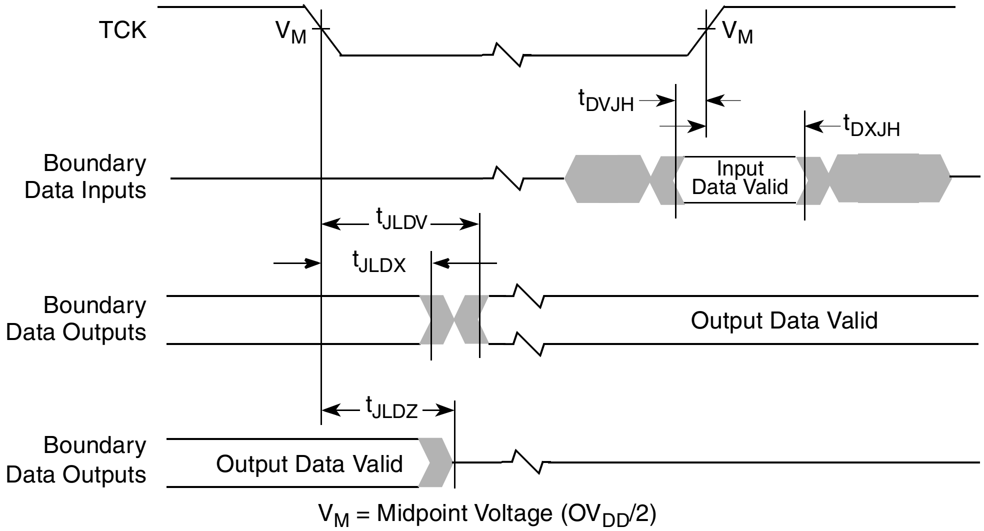


Figure 10. Boundary-Scan Timing Diagram

Table 11. Pinout Listing for the MPC7448, 360 HCTE Package

Signal Name	Pin Number	Active	I/O	Notes
A[0:35]	E11, H1, C11, G3, F10, L2, D11, D1, C10, G2, D12, L3, G4, T2, F4, V1, J4, R2, K5, W2, J2, K4, N4, J3, M5, P5, N3, T1, V2, U1, N5, W1, B12, C4, G10, B11	High	I/O	2
$\overline{\text{AACK}}$	R1	Low	Input	
AP[0:4]	C1, E3, H6, F5, G7	High	I/O	2
$\overline{\text{ARTRY}}$	N2	Low	I/O	3
AV_{DD}	A8	—	Input	
$\overline{\text{BG}}$	M1	Low	Input	
$\overline{\text{BMODE0}}$	G9	Low	Input	4
$\overline{\text{BMODE1}}$	F8	Low	Input	5
$\overline{\text{BR}}$	D2	Low	Output	
BVSEL0	B7	High	Input	1, 6
BVSEL1	E10	High	Input	1, 20
$\overline{\text{CI}}$	J1	Low	Output	
$\overline{\text{CKSTP\_IN}}$	A3	Low	Input	
$\overline{\text{CKSTP\_OUT}}$	B1	Low	Output	
CLK_OUT	H2	High	Output	
D[0:63]	R15, W15, T14, V16, W16, T15, U15, P14, V13, W13, T13, P13, U14, W14, R12, T12, W12, V12, N11, N10, R11, U11, W11, T11, R10, N9, P10, U10, R9, W10, U9, V9, W5, U6, T5, U5, W7, R6, P7, V6, P17, R19, V18, R18, V19, T19, U19, W19, U18, W17, W18, T16, T18, T17, W3, V17, U4, U8, U7, R7, P6, R8, W8, T8	High	I/O	
$\overline{\text{DBG}}$	M2	Low	Input	
$\overline{\text{DFS2}}$	A12	Low	Input	20, 21
$\overline{\text{DFS4}}$	B6	Low	Input	12, 20, 21
DP[0:7]	T3, W4, T4, W9, M6, V3, N8, W6	High	I/O	
$\overline{\text{DRDY}}$	R3	Low	Output	7
DTI[0:3]	G1, K1, P1, N1	High	Input	8
EXT_QUAL	A11	High	Input	9
$\overline{\text{GBL}}$	E2	Low	I/O	
GND	B5, C3, D6, D13, E17, F3, G17, H4, H7, H9, H11, H13, J6, J8, J10, J12, K7, K3, K9, K11, K13, L6, L8, L10, L12, M4, M7, M9, M11, M13, N7, P3, P9, P12, R5, R14, R17, T7, T10, U3, U13, U17, V5, V8, V11, V15	—	—	
GND	A17, A19, B13, B16, B18, E12, E19, F13, F16, F18, G19, H18, J14, L14, M15, M17, M19, N14, N16, P15, P19	—	—	15
GND_SENSE	G12, N13	—	—	19
$\overline{\text{HIT}}$	B2	Low	Output	7
$\overline{\text{HRESET}}$	D8	Low	Input	
$\overline{\text{INT}}$	D4	Low	Input	
L1_TSTCLK	G8	High	Input	9
L2_TSTCLK	B3	High	Input	10

Table 11. Pinout Listing for the MPC7448, 360 HCTE Package (continued)

Signal Name	Pin Number	Active	I/O	Notes
VDD_SENSE	G13, N12	—	—	18

Notes:

1. OV_{DD} supplies power to the processor bus, JTAG, and all control signals, and is configurable. (V_{DD} supplies power to the processor core, and AV_{DD} supplies power to the PLL after filtering from V_{DD}). To program the I/O voltage, see Table 3. If used, the pull-down resistor should be less than 250 Ω. Because these settings may change in future products, it is recommended BVSEL[0:1] be configured using resistor options, jumpers, or some other flexible means, with the capability to reconfigure the termination of this signal in the future if necessary. For actual recommended value of V_{in} or supply voltages see Table 4.
2. Unused address pins must be pulled down to GND and corresponding address parity pins pulled up to OV_{DD}.
3. These pins require weak pull-up resistors (for example, 4.7 KΩ) to maintain the control signals in the negated state after they have been actively negated and released by the MPC7448 and other bus masters.
4. This signal selects between MPX bus mode (asserted) and 60x bus mode (negated) and will be sampled at $\overline{\text{HRESET}}$ going high.
5. This signal must be negated during reset, by pull-up resistor to OV_{DD} or negation by ¬$\overline{\text{HRESET}}$ (inverse of $\overline{\text{HRESET}}$), to ensure proper operation.
6. Internal pull up on die.
7. Not used in 60x bus mode.
8. These signals must be pulled down to GND if unused, or if the MPC7448 is in 60x bus mode.
9. These input signals are for factory use only and must be pulled down to GND for normal machine operation.
10. This test signal is recommended to be tied to $\overline{\text{HRESET}}$; however, other configurations will not adversely affect performance.
11. These signals are for factory use only and must be left unconnected for normal machine operation. Some pins that were NCs on the MPC7447, MPC7445, and MPC7441 have now been defined for other purposes.
12. These input signals are for factory use only and must be pulled up to OV_{DD} for normal machine operation.
13. This pin can externally cause a performance monitor event. Counting of the event is enabled through software.
14. This signal must be asserted during reset, by pull down to GND or assertion by $\overline{\text{HRESET}}$, to ensure proper operation.
15. These pins were NCs on the MPC7447, MPC7445, and MPC7441. See Section 9.3, "Connection Recommendations," for more information.
16. These pins were OV_{DD} pins on the MPC7447, MPC7445, and MPC7441. These pins are internally connected to OV_{DD} and are intended to allow an external device (such as a power supply) to detect the I/O voltage level present inside the device package. If unused, it is recommended they be connected to test points to facilitate system debug; otherwise, they may be connected directly to OV_{DD} or left unconnected.
17. These pins provide connectivity to the on-chip temperature diode that can be used to determine the die junction temperature of the processor. These pins may be left unterminated if unused.
18. These pins are internally connected to V_{DD} and are intended to allow an external device (such as a power supply) to detect the processor core voltage level present inside the device package. If unused, it is recommended they be connected to test points to facilitate system debug; otherwise, they may be connected directly to V_{DD} or left unconnected.
19. These pins are internally connected to GND and are intended to allow an external device to detect the processor ground voltage level present inside the device package. If unused, it is recommended they be connected to test points to facilitate system debug; otherwise, they may be connected directly to GND or left unconnected.
20. These pins were in the TEST[0:4] factory test pin group on the MPC7447A, MPC7447, MPC7445, and MPC7441. They have been assigned new functions on the MPC7448.
21. These pins can be used to enable the supported dynamic frequency switching (DFS) modes via hardware. If both are pulled down, DFS mode is disabled completely and cannot be enabled via software. If unused, they should be pulled up to OV_{DD} to allow software control of DFS. See the *MPC7450 RISC Microprocessor Family Reference Manual* for more information.
22. This pin is provided to allow operation of the L2 cache at low core voltages and is for factory use only. See the *MPC7450 RISC Microprocessor Family Reference Manual* for more information.

8.3 Package Parameters for the MPC7448, 360 HCTE LGA

The package parameters are as provided in the following list. The package type is 25 × 25 mm, 360 pin high coefficient of thermal expansion ceramic land grid array (HCTE).

Package outline	25 × 25 mm
Interconnects	360 (19 × 19 ball array – 1)
Pitch	1.27 mm (50 mil)
Minimum module height	1.52 mm
Maximum module height	1.80 mm
Pad diameter	0.89 mm (35 mil)
Coefficient of thermal expansion	12.3 ppm/°C

Table 12. MPC7448 Microprocessor PLL Configuration Example (continued)

PLL_CFG[0:5]	Example Core and VCO Frequency in MHz										
	Bus-to-Core Multiplier [5]	Core-to-VCO Multiplier [5]	Bus (SYSCLK) Frequency								
			33.3 MHz	50 MHz	66.6 MHz	75 MHz	83 MHz	100 MHz	133 MHz	167 MHz	200 MHz
100110	11x	1x			733	825	913	1100	1467		
000000	11.5x	1x			766	863	955	1150	1533		
101110	12x	1x		600	800	900	996	1200	1600		
111110	12.5x	1x		625	833	938	1038	1250	1667		
010110	13x	1x		650	865	975	1079	1300			
111000	13.5x	1x		675	900	1013	1121	1350			
110010	14x	1x		700	933	1050	1162	1400			
000110	15x	1x		750	1000	1125	1245	1500			
110110	16x	1x		800	1066	1200	1328	1600			
000010	17x	1x		850	1132	1275	1417	1700			
001010	18x	1x	600	900	1200	1350	1500				
001110	20x	1x	667	1000	1332	1500	1666				
010010	21x	1x	700	1050	1399	1575					
011010	24x	1x	800	1200	1600						
111010	28x	1x	933	1400							
001100	PLL bypass		PLL off, SYSCLK clocks core circuitry directly								
111100	PLL off		PLL off, no core clocking occurs								

Notes:

1. PLL_CFG[0:5] 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 MPC7448; see Section 5.2.1, "Clock AC Specifications," for valid SYSCLK, core, and VCO frequencies.
3. In PLL-bypass mode, the SYSCLK input signal clocks the internal processor directly and the PLL is disabled. However, the bus interface unit requires a 2x clock to function. Therefore, an additional signal, EXT_QUAL, must be driven at half the frequency of SYSCLK and offset in phase to meet the required input setup t_{IVKH} and hold time t_{IXKH} (see Table 9). The result will be that the processor bus frequency will be one-half SYSCLK, while the internal processor is clocked at SYSCLK frequency. This mode is intended for factory use and emulator tool 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 MPC7448 regardless of the SYSCLK input.
5. Applicable when DFS modes are disabled. These multipliers change when operating in a DFS mode. See Section 9.7.5, "Dynamic Frequency Switching (DFS)" for more information.
6. Bus-to-core multipliers less than 5x require that assertion of AACK be delayed by one or two bus cycles to allow the processor to generate a response to a snooped transaction. See the *MPC7450 RISC Microprocessor Reference Manual* for more information.

These requirements are shown graphically in Figure 16.

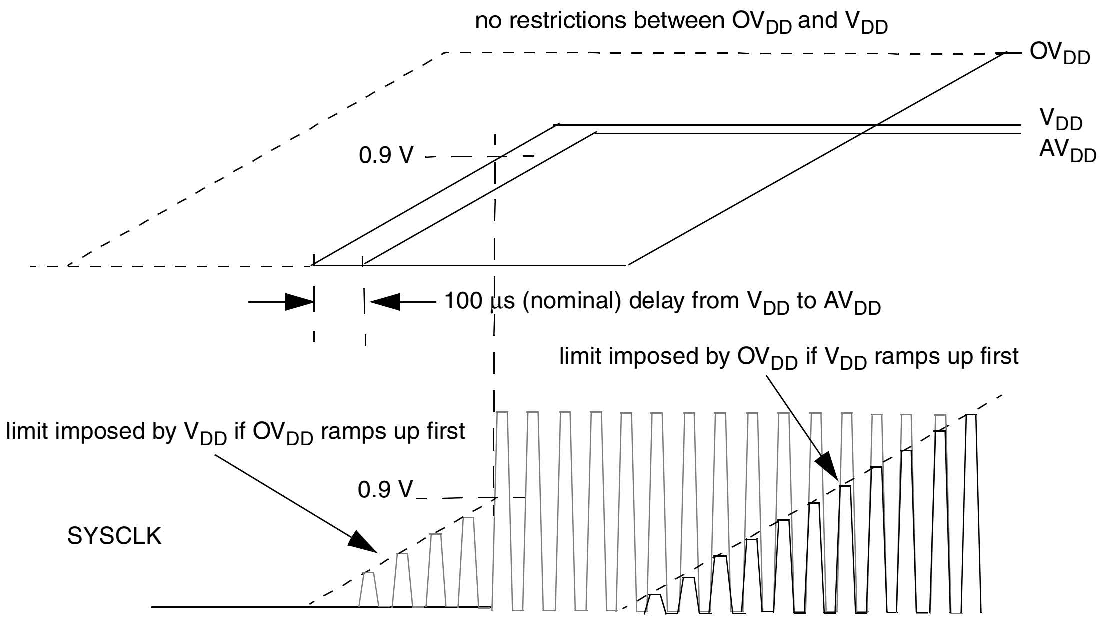


Figure 16. MPC7448 Power Up Sequencing Requirements

Certain stipulations also apply to the manner in which the power rails of the MPC7448 power down, as follows:

- OV_{DD} may ramp down any time before or after V_{DD}.
- The voltage at the SYSCLK input must not exceed V_{DD} once V_{DD} has ramped down below 0.9 V.
- The voltage at the SYSCLK input must not exceed OV_{DD} by more 20% during transients (see overshoot/undershoot specifications in Figure 2) or 0.3 V DC (see Table 2) at any time.

9.2.4 Decoupling Recommendations

Due to the MPC7448 dynamic power management feature, large address and data buses, and high operating frequencies, the MPC7448 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 MPC7448 system, and the MPC7448 itself requires a clean, tightly regulated source of power. Therefore, it is recommended that the system designer use sufficient decoupling capacitors, typically one capacitor for every V_{DD} pin, and a similar amount for the OV_{DD} pins, placed as close as possible to the power pins of the MPC7448. It is also recommended that these decoupling capacitors receive their power from separate V_{DD}, OV_{DD}, and GND power planes in the PCB, using short traces to minimize inductance.

These capacitors should have a value of 0.01 or 0.1 µF. Only ceramic surface mount technology (SMT) capacitors should be used to minimize lead inductance. Orientations where connections are made along the length of the part, such as 0204, are preferable but not mandatory. Consistent with the recommendations of Dr. Howard Johnson in *High Speed Digital Design: A Handbook of Black Magic* (Prentice Hall, 1993) and contrary to previous recommendations for decoupling Freescale microprocessors, multiple small capacitors of equal value are recommended over using multiple values of capacitance.

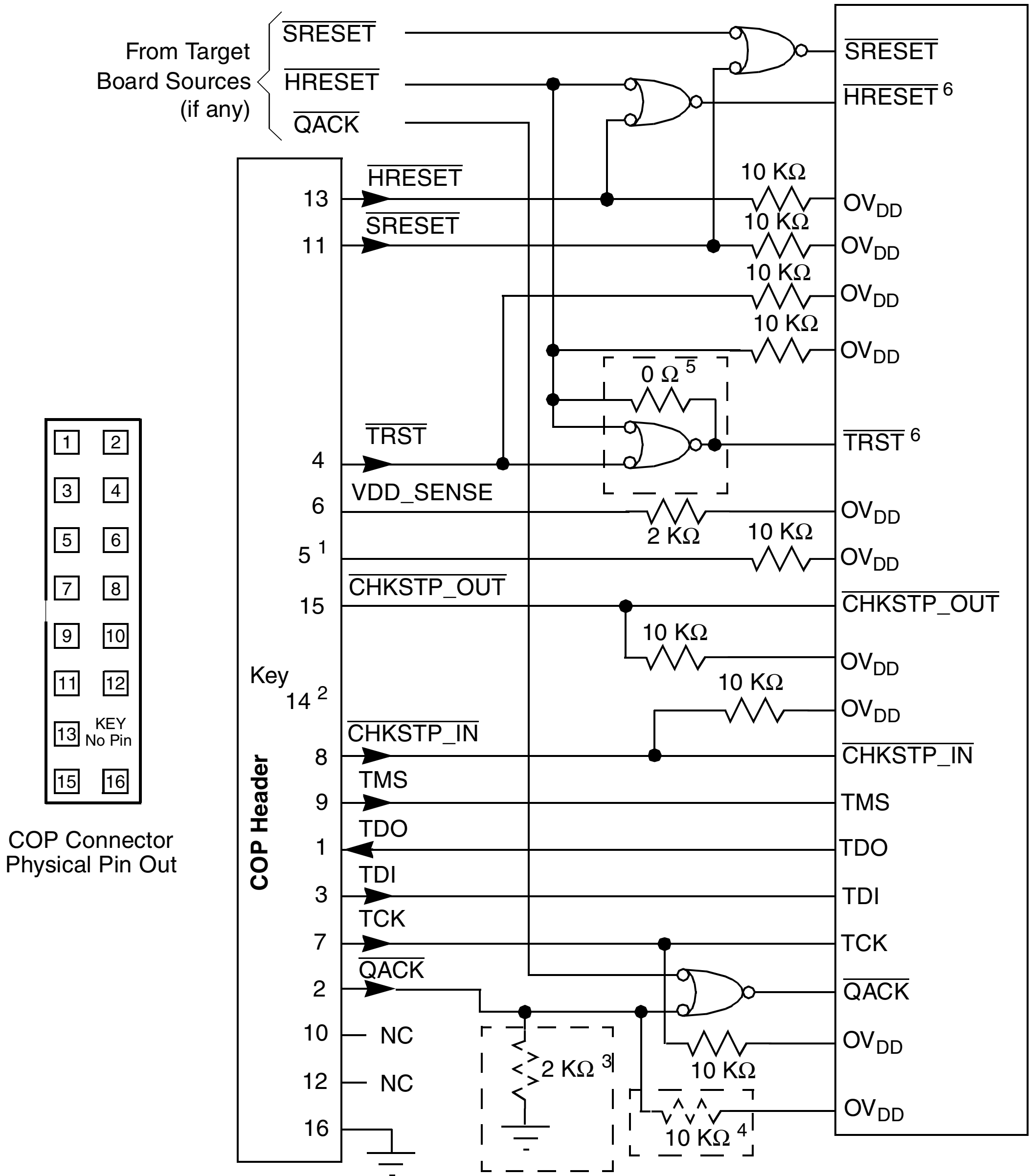
In addition, it is recommended that there be several bulk storage capacitors distributed around the PCB, feeding the V_{DD} and OV_{DD} planes, to enable quick recharging of the smaller chip capacitors. These bulk capacitors should have a low equivalent series resistance (ESR) rating to ensure the quick response time necessary. They should also be connected to the power and ground planes through two vias to minimize inductance. Suggested bulk capacitors are 100–330 µF (AVX TPS tantalum or Sanyo OSCON).

9.3 Connection Recommendations

To ensure reliable operation, it is highly recommended to connect unused inputs to an appropriate signal level. Unless otherwise noted, unused active low inputs should be tied to OV_{DD} and 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}, and GND pins in the MPC7448. For backward compatibility with the MPC7447, MPC7445, and MP7441, or for migrating a system originally designed for one of these devices to the MPC7448, the new power and ground signals (formerly NC, see Table 11) may be left unconnected if the core frequency is 1 GHz or less. Operation above 1 GHz requires that these additional power and ground signals be connected, and it is strongly recommended that all new designs include the additional connections. See also Section 7, “Pinout Listings,” for additional information.

The MPC7448 provides VDD_SENSE, OVDD_SENSE, and GND_SENSE pins. These pins connect directly to the power/ground planes in the device package and are intended to allow an external device to measure the voltage present on the V_{DD}, OV_{DD} and GND planes in the device package. The most common use for these signals is as a feedback signal to a power supply regulator to allow it to compensate for board losses and supply the correct voltage at the device. (Note that all voltage parameters are specified at the pins of the device.) If not used for this purpose, it is recommended that these signals be connected to test points that can be used in the event that an accurate measurement of the voltage at the device is needed during system debug. Otherwise, these signals should be connected to the appropriate power/ground planes on the circuit board or left unconnected.



Notes:

1. RUN/$\overline{\text{STOP}}$, normally found on pin 5 of the COP header, is not implemented on the MPC7448. Connect pin 5 of the COP header to OV_{DD} with a 10-KΩ pull-up resistor.
2. Key location; pin 14 is not physically present on the COP header.
3. Component not populated. Populate only if debug tool does not drive $\overline{\text{QACK}}$.
4. Populate only if debug tool uses an open-drain type output and does not actively negate $\overline{\text{QACK}}$.
5. If the JTAG interface is implemented, connect $\overline{\text{HRESET}}$ from the target source to $\overline{\text{TRST}}$ from the COP header though an AND gate to $\overline{\text{TRST}}$ of the part. If the JTAG interface is not implemented, connect $\overline{\text{HRESET}}$ from the target source to $\overline{\text{TRST}}$ of the part through a 0-Ω isolation resistor.
6. The COP port and target board should be able to independently assert $\overline{\text{HRESET}}$ and $\overline{\text{TRST}}$ to the processor in order to fully control the processor as shown above.

Figure 21. JTAG Interface Connection

9.7 Power and Thermal Management Information

This section provides thermal management information for the high coefficient of thermal expansion (HCTE) 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. The MPC7448 implements several features designed to assist with thermal management, including DFS and the temperature diode. DFS reduces the power consumption of the device by reducing the core frequency; see Section 9.7.5.1, "Power Consumption with DFS Enabled," for specific information regarding power reduction and DFS. The temperature diode allows an external device to monitor the die temperature in order to detect excessive temperature conditions and alert the system; see Section 9.7.4, "Temperature Diode," for more information.

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 22); however, due to the potential large mass of the heat sink, attachment through the printed-circuit board is suggested. In any implementation of a heat sink solution, the force on the die should not exceed ten pounds (45 Newtons).

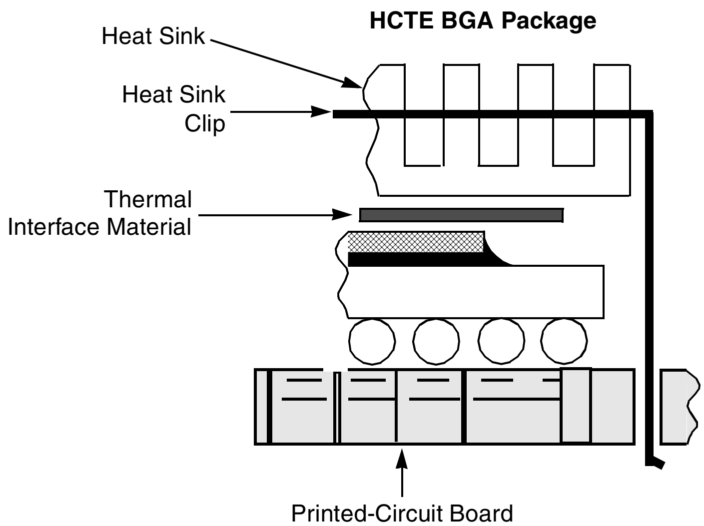


Figure 22. BGA Package Exploded Cross-Sectional View with Several Heat Sink Options

NOTE

A clip on heat sink is not recommended for LGA because there may not be adequate clearance between the device and the circuit board. A through-hole solution is recommended, as shown in Figure 23.

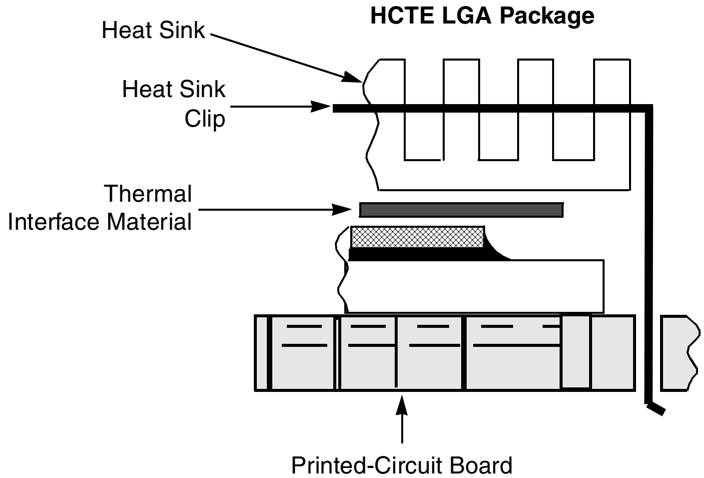


Figure 23. LGA Package Exploded Cross-Sectional View with Several Heat Sink Options

There are several commercially-available heat sinks for the MPC7448 provided by the following vendors:

Aavid Thermalloy 80 Commercial St. Concord, NH 03301 Internet: www.aavidthermalloy.com	603-224-9988
Alpha Novatech 473 Sapena Ct. #12 Santa Clara, CA 95054 Internet: www.alphanovatech.com	408-567-8082
Calgreg Thermal Solutions 60 Alhambra Road, Suite 1 Warwick, RI 02886 Internet: www.calgregthermalsolutions.com	888-732-6100
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.tycoelectronics.com	800-522-6752
Wakefield Engineering 33 Bridge St. Pelham, NH 03076 Internet: www.wakefield.com	603-635-2800

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.

Table 16. Valid Divide Ratio Configurations

DFS mode disabled		DFS divide-by-2 mode enabled (HID1[DFS2] = 1 or $\overline{DFS2}$ = 0)		DFS divide-by-4 mode enabled (HID1[DFS4] = 1 or $\overline{DFS4}$ = 0)	
Bus-to-Core Multiplier Configured by PLL_CFG[0:5] (see Table 12)	HID1[PC0-5] [3]	Bus-to-Core Multiplier	HID1[PC0-5] [3]	Bus-to-Core Multiplier	HID1[PC0-5] [3]
2x [4]	010000	N/A (unchanged) [1]	unchanged [1]	N/A (unchanged) [1]	unchanged [1]
3x [4]	100000	N/A (unchanged) [1]	unchanged [1]	N/A (unchanged) [1]	unchanged [1]
4x [4]	101000	2x [4]	010000	N/A (unchanged) [1]	unchanged [1]
5x	101100	2.5x [4]	010101	N/A (unchanged) [1]	unchanged [1]
5.5x	100100	2.75x [4]	110101 [2]	N/A (unchanged) [1]	unchanged [1]
6x	110100	3x [4]	100000	N/A (unchanged) [1]	unchanged [1]
6.5x	010100	3.25x [4]	100000 [2]	N/A (unchanged) [1]	unchanged [1]
7x	001000	3.5x [4]	110101	N/A (unchanged) [1]	unchanged [1]
7.5x	000100	3.75x [4]	110101 [2]	N/A (unchanged) [1]	unchanged [1]
8x	110000	4x [4]	101000 [4]	2x [4]	010000
8.5x	011000	4.25x [4]	101000 [2]	N/A (unchanged) [1]	unchanged [1]
9x	011110	4.5x [4]	011101	2.25x [4]	010000 [2]
9.5x	011100	4.75x [4]	011101 [2]	N/A (unchanged) [1]	unchanged [1]
10x	101010	5x	101100	2.5x [4]	010101
10.5x	100010	5.25x	101100 [2]	N/A (unchanged) [1]	unchanged [1]
11x	100110	5.5x	100100	2.75x [4]	010101 [2]
11.5x	000000	5.75x	100100 [2]	N/A (unchanged) [1]	unchanged [1]
12x	101110	6x	110100	3x [4]	100000
12.5x	111110	6.25x	110100 [2]	N/A (unchanged) [1]	unchanged [1]
13x	010110	6.5x	010100	3.25x [4]	100000 [2]
13.5x	111000	6.75	010100 [2]	N/A (unchanged) [1]	unchanged [1]
14x	110010	7x	001000	3.5x [4]	110101
15x	000110	7.5x	000100	3.75x [4]	110101 [2]
16x	110110	8x	110000	4x [4]	101000
17x	000010	8.5x	011000	4.25x [4]	101000 [2]
18x	001010	9x	011110	4.5x [4]	011101
20x	001110	10x	101010	5x	101100
21x	010010	10.5x	100010	5.25x	101100 [2]

11 Part Numbering and Marking

Ordering information for the part numbers fully covered by this specification document is provided in Section 11.1, "Part Numbers Fully Addressed by This Document." Note that the individual part numbers correspond to a maximum processor core frequency. For available frequencies, contact a local Freescale sales office. In addition to the processor frequency, the part numbering scheme also includes an application modifier that may specify special application conditions. An optional specification modifier may also apply for parts to indicate a specific change in specifications, such as support for an extended temperature range. Finally, each part number contains a revision level code that refers to the die mask revision number. Section 11.2, "Part Numbers Not Fully Addressed by This Document," lists the part numbers that do not fully conform to the specifications of this document. These special part numbers require an additional document called a hardware specification addendum.

11.1 Part Numbers Fully Addressed by This Document

Table 18 provides the Freescale part numbering nomenclature for the MPC7448 part numbers fully addressed by this document. For information regarding other MPC7448 part numbers, see Section 11.2, "Part Numbers Not Fully Addressed by This Document."

Table 18. Part Numbering Nomenclature

xx	**7448**	***xx***	***nnnn***	**L**	***x***
Product Code	**Part Identifier**	**Package**	**Processor Frequency**	**Application Modifier**	**Revision Level**
MC PPC [1]	7448	HX = HCTE BGA VS = RoHS LGA VU = RoHS BGA	1700	L: 1.3 V +20/–50 mV 0 to 105 °C	C: 2.1; PVR = 0x8004_0201 D: 2.2; PVR = 0x8004_0202
			1600	L: 1.25 V ± 50 mV 0 to 105 °C	
			1420	L: 1.2 V ± 50 mV 0 to 105 °C	
			1000	L: 1.15 V ± 50 mV 0 to 105 °C	

Notes:

1. The P prefix in a Freescale part number designates a "Pilot Production Prototype" as defined by Freescale SOP 3-13. These parts have only preliminary reliability and characterization data. Before pilot production prototypes may be shipped, written authorization from the customer must be on file in the applicable sales office acknowledging the qualification status and the fact that product changes may still occur as pilot production prototypes are shipped.

How to Reach Us:

Home Page:
www.freescale.com

email:
support@freescale.com

USA/Europe or Locations Not Listed:
Freescale Semiconductor
Technical Information Center, CH370
1300 N. Alma School Road
Chandler, Arizona 85224
1-800-521-6274
480-768-2130
support@freescale.com

Europe, Middle East, and Africa:
Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
support@freescale.com

Japan:
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku
Tokyo 153-0064, Japan
0120 191014
+81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:
Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
2 Dai King Street
Tai Po Industrial Estate,
Tai Po, N.T., Hong Kong
+800 2666 8080
support.asia@freescale.com

For Literature Requests Only:
Freescale Semiconductor
Literature Distribution Center
P.O. Box 5405
Denver, Colorado 80217
1-800-441-2447
303-675-2140
Fax: 303-675-2150
LDCForFreescaleSemiconductor
@hibbertgroup.com

Document Number: MPC7448EC
Rev. 4
3/2007