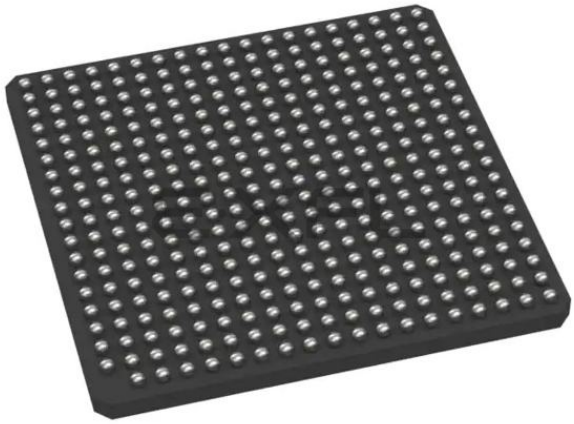


Welcome to E-XFL.COM

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	600MHz
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-CBGA, FCCBGA
Supplier Device Package	360-FCCBGA (25x25)
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/mc7448vu600nc

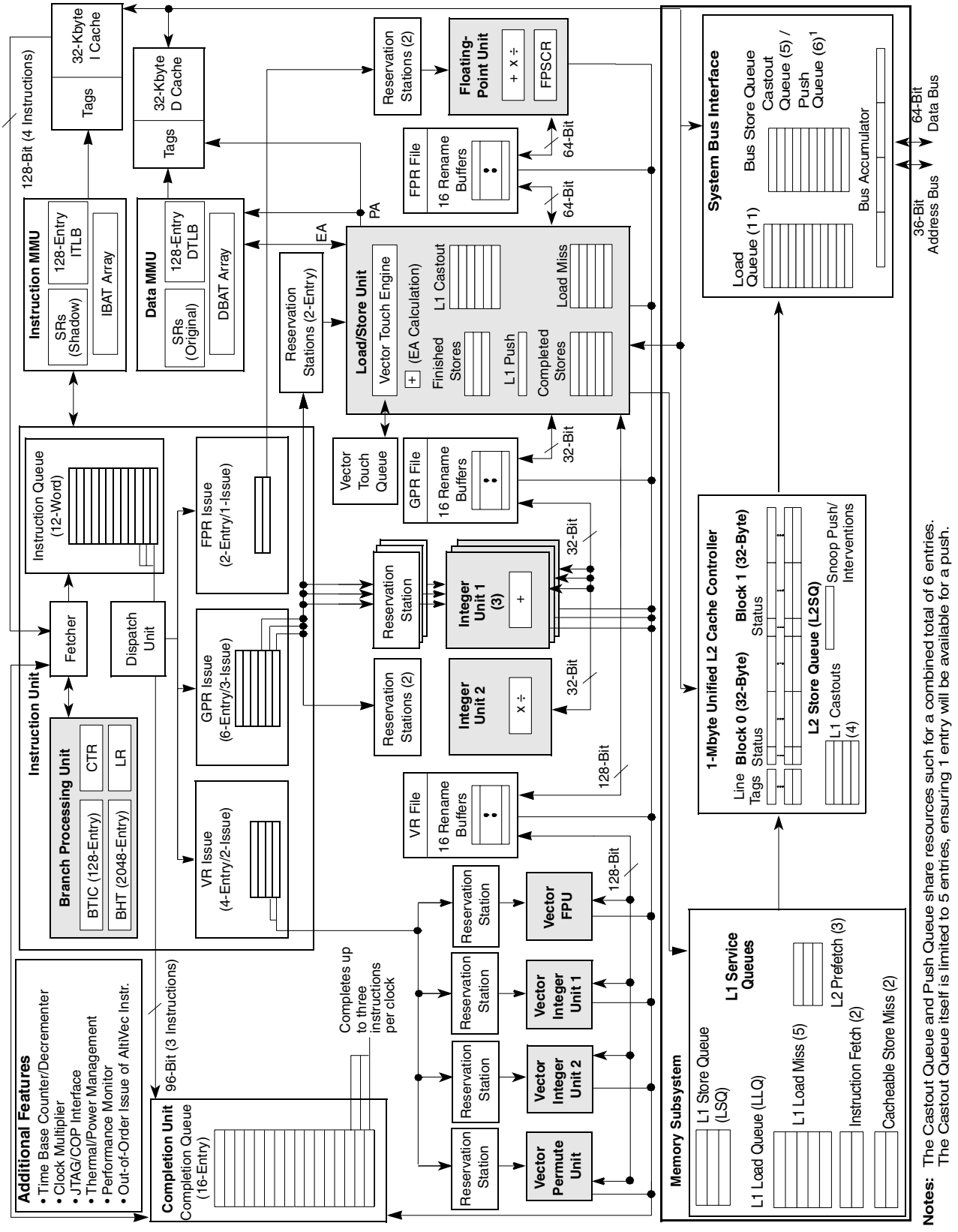


Figure 1. MPC7448 Block Diagram

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).

4 General Parameters

The following list summarizes the general parameters of the MPC7448:

Technology	90 nm CMOS SOI, nine-layer metal	
Die size	8.0 mm × 7.3 mm	
Transistor count	90 million	
Logic design	Mixed static and dynamic	
Packages	Surface mount 360 ceramic ball grid array (HCTE)	
	Surface mount 360 ceramic land grid array (HCTE)	
	Surface mount 360 ceramic ball grid array with lead-free spheres (HCTE)	
Core power supply	1.30 V	(1700 MHz device)
	1.25 V	(1600 MHz device)
	1.20 V	(1420 MHz device)
	1.15 V	(1000 MHz device)
I/O power supply	1.5 V, 1.8 V, or 2.5 V	

5 Electrical and Thermal Characteristics

This section provides the AC and DC electrical specifications and thermal characteristics for the MPC7448.

5.1 DC Electrical Characteristics

The tables in this section describe the MPC7448 DC electrical characteristics. Table 2 provides the absolute maximum ratings. See Section 9.2, “Power Supply Design and Sequencing,” for power sequencing requirements.

Table 2. Absolute Maximum Ratings [1]

Characteristic		Symbol	Maximum Value	Unit	Notes
Core supply voltage		V_{DD}	–0.3 to 1.4	V	2
PLL supply voltage		AV_{DD}	–0.3 to 1.4	V	2
Processor bus supply voltage	I/O Voltage Mode = 1.5 V	OV_{DD}	–0.3 to 1.8	V	3
	I/O Voltage Mode = 1.8 V		–0.3 to 2.2		3
	I/O Voltage Mode = 2.5 V		–0.3 to 3.0		3
Input voltage	Processor bus	V_{in}	–0.3 to OV_{DD} + 0.3	V	4
	JTAG signals	V_{in}	–0.3 to OV_{DD} + 0.3	V	
Storage temperature range		T_{stg}	– 55 to 150	•C	

Notes:

1. Functional and tested operating conditions are given in Table 4. 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. See Section 9.2, “Power Supply Design and Sequencing” for power sequencing requirements.
3. Bus must be configured in the corresponding I/O voltage mode; see Table 3.
4. **Caution**: V_{in} must not exceed OV_{DD} by more than 0.3 V at any time including during power-on reset except as allowed by the overshoot specifications. V_{in} 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 MPC7448.

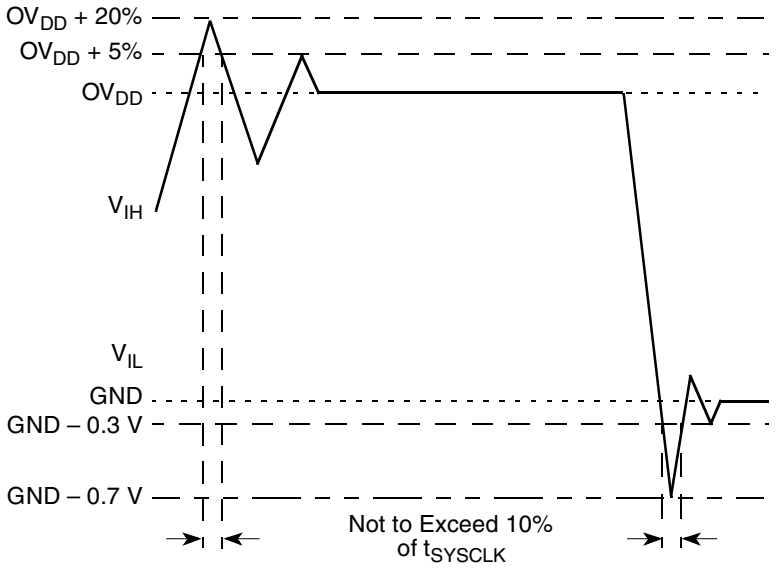


Figure 2. Overshoot/Undershoot Voltage

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 4 provides the recommended operating conditions for the MPC7448 part numbers described by this document; see Section 11.1, “Part Numbers Fully Addressed by This Document,” for more information. See Section 9.2, “Power Supply Design and Sequencing” for power sequencing requirements.

Table 4. Recommended Operating Conditions[1]

Characteristic		Symbol	Recommended Value								Unit	Notes
			1000 MHz		1420 MHz		1600 MHz		1700 MHz			
			Min	Max	Min	Max	Min	Max	Min	Max		
Core supply voltage		V_{DD}	1.15 V ± 50 mV		1.2 V ± 50 mV		1.25 V ± 50 mV		1.3 V +20/ – 50 mV		V	3, 4, 5
PLL supply voltage		AV_{DD}	1.15 V ± 50 mV		1.2 V ± 50 mV		1.25 V ± 50 mV		1.3 V +20/ – 50 mV		V	2, 3, 4
Processor bus supply voltage	I/O Voltage Mode = 1.5 V	OV_{DD}	1.5 V ± 5%		1.5 V ± 5%		1.5 V ± 5%		1.5 V ± 5%		V	4
	I/O Voltage Mode = 1.8 V		1.8 V ± 5%		1.8 V ± 5%		1.8 V ± 5%		1.8 V ± 5%			4
	I/O Voltage Mode = 2.5 V		2.5 V ± 5%		2.5 V ± 5%		2.5 V ± 5%		2.5 V ± 5%			4
Input voltage	Processor bus	V_{in}	GND	OV_{DD}	GND	OV_{DD}	GND	OV_{DD}	GND	OV_{DD}	V	
	JTAG signals	V_{in}	GND	OV_{DD}	GND	OV_{DD}	GND	OV_{DD}	GND	OV_{DD}		
Die-junction temperature		T_j	0	105	0	105	0	105	0	105	•C	6

Notes:

1. These are the recommended and tested operating conditions.
2. This voltage is the input to the filter discussed in Section 9.2.2, “PLL Power Supply Filtering,” and not necessarily the voltage at the AV_{DD} pin, which may be reduced from V_{DD} by the filter.
3. Some early devices supported voltage and frequency derating whereby VDD (and AVDD) could be reduced to reduce power consumption. This feature has been superseded and is no longer supported. See Section 5.3, “Voltage and Frequency Derating,” for more information.
4. **Caution**: Power sequencing requirements must be met; see Section 9.2, “Power Supply Design and Sequencing”.
5. **Caution**: See Section 9.2.3, “Transient Specifications” for information regarding transients on this power supply.
6. For information on extended temperature devices, see Section 11.2, “Part Numbers Not Fully Addressed by This Document.”

Table 5 provides the package thermal characteristics for the MPC7448. For more information regarding thermal management, see Section 9.7, "Power and Thermal Management Information."

Table 5. Package Thermal Characteristics[1]

Characteristic	Symbol	Value	Unit	Notes
Junction-to-ambient thermal resistance, natural convection, single-layer (1s) board	$R_{\theta JA}$	26	•C/W	2, 3
Junction-to-ambient thermal resistance, natural convection, four-layer (2s2p) board	$R_{\theta JMA}$	19	•C/W	2, 4
Junction-to-ambient thermal resistance, 200 ft/min airflow, single-layer (1s) board	$R_{\theta JMA}$	22	•C/W	2, 4
Junction-to-ambient thermal resistance, 200 ft/min airflow, four-layer (2s2p) board	$R_{\theta JMA}$	16	•C/W	2, 4
Junction-to-board thermal resistance	$R_{\theta JB}$	11	•C/W	5
Junction-to-case thermal resistance	$R_{\theta JC}$	< 0.1	•C/W	6

Notes:

1. Refer to Section 9.7, "Power and Thermal Management Information," for details about thermal management.
2. Junction temperature is a function of on-chip power dissipation, package thermal resistance, mounting site (board) temperature, ambient temperature, airflow, power dissipation of other components on the board, and board thermal resistance.
3. Per JEDEC JESD51-2 with the single-layer board horizontal
4. Per JEDEC JESD51-6 with the board horizontal
5. Thermal resistance between the die and the printed-circuit board per JEDEC JESD51-8. Board temperature is measured on the top surface of the board near the package.
6. This is the thermal resistance between die and case top surface as measured by the cold plate method (MIL SPEC-883 Method 1012.1) with the calculated case temperature. The actual value of $R_{\theta JC}$ for the part is less than 0.1°C/W.

Table 6 provides the DC electrical characteristics for the MPC7448.

Table 6. DC Electrical Specifications

At recommended operating conditions. See Table 4.

Characteristic	Nominal Bus Voltage [1]	Symbol	Min	Max	Unit	Notes
Input high voltage (all inputs)	1.5	V_{IH}	$OV_{DD} \times 0.65$	$OV_{DD} + 0.3$	V	2
	1.8		$OV_{DD} \times 0.65$	$OV_{DD} + 0.3$		
	2.5		1.7	$OV_{DD} + 0.3$		
Input low voltage (all inputs)	1.5	V_{IL}	–0.3	$OV_{DD} \times 0.35$	V	2
	1.8		–0.3	$OV_{DD} \times 0.35$		
	2.5		–0.3	0.7		
Input leakage current, all signals except BVSEL0, LSSD_MODE, TCK, TDI, TMS, TRST: $V_{in} = OV_{DD}$ V_{in} = GND	—	I_{in}	—	 50 – 50	µA	2, 3
Input leakage current, BVSEL0, LSSD_MODE, TCK, TDI, TMS, TRST: $V_{in} = OV_{DD}$ V_{in} = GND	—	I_{in}	—	 50 – 2000	µA	2, 6

when running a typical benchmark at temperatures in a typical system. The Full-Power Mode–Thermal value is intended to represent the sustained power consumption of the device when running a typical code sequence at high temperature and is recommended to be used as the basis for designing a thermal solution; see Section 9.7, "Power and Thermal Management Information" for more information on thermal solutions. The Full-Power Mode–Maximum value is recommended to be used for power supply design because this represents the maximum peak power draw of the device that a power supply must be capable of sourcing without voltage droop. For information on power consumption when dynamic frequency switching is enabled, see Section 9.7.5, "Dynamic Frequency Switching (DFS)."

Table 7. Power Consumption for MPC7448 at Maximum Rated Frequency

	Die Junction Temperature (T_j)	Maximum Processor Core Frequency (Speed Grade, MHz)				Unit	Notes
		1000 MHz	1420 MHz	1600 MHz	1700 MHz		
Full-Power Mode							
Typical	65 •C	15.0	19.0	20.0	21.0	W	1, 2
Thermal	105 •C	18.6	23.3	24.4	25.6	W	1, 5
Maximum	105 •C	21.6	27.1	28.4	29.8	W	1, 3
Nap Mode							
Typical	105 •C	11.1	11.8	13.0	13.0	W	1, 6
Sleep Mode							
Typical	105 •C	10.8	11.4	12.5	12.5	W	1, 6
Deep Sleep Mode (PLL Disabled)							
Typical	105 •C	10.4	11.0	12.0	12.0	W	1, 6

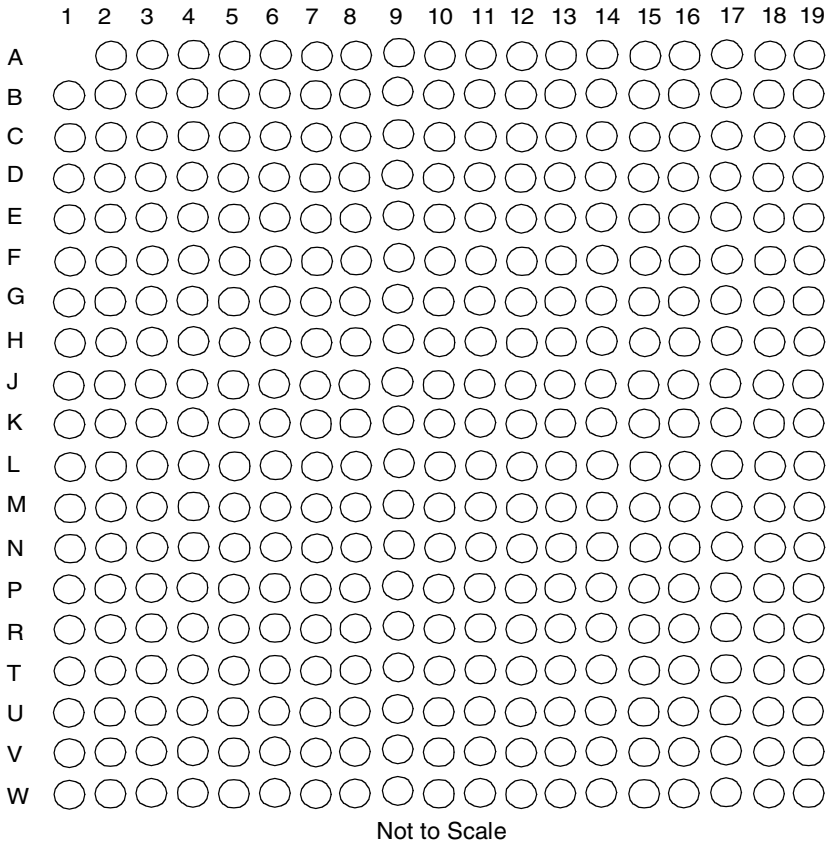
Notes:

1. These values specify the power consumption for the core power supply (V_{DD}) at nominal voltage and apply to all valid processor bus frequencies and configurations. The values do not include I/O supply power (OV_{DD}) or PLL supply power (AV_{DD}). OV_{DD} power is system dependent but is typically < 5% of V_{DD} power. Worst case power consumption for AV_{DD} < 13 mW. Freescale also offers MPC7448 part numbers that meet lower power consumption specifications; for more information on these devices, see Section 11.2, "Part Numbers Not Fully Addressed by This Document."
2. Typical power consumption is an average value measured with the processor operating at its rated maximum processor core frequency (except for Deep Sleep Mode), at nominal recommended V_{DD} (see Table 4) and 65°C while running the Dhrystone 2.1 benchmark and achieving 2.3 Dhrystone MIPs/MHz. This parameter is not 100% tested but periodically sampled.b
3. Maximum power consumption is the average measured with the processor operating at its rated maximum processor core frequency, at nominal V_{DD} and maximum operating junction temperature (see Table 4) while running an entirely cache-resident, contrived sequence of instructions to keep all the execution units maximally busy.
4. Doze mode is not a user-definable state; it is an intermediate state between full-power and either nap or sleep mode. As a result, power consumption for this mode is not tested.
5. Thermal power consumption is an average value measured at the nominal recommended V_{DD} (see Table 4) and 105 °C while running the Dhrystone 2.1 benchmark and achieving 2.3 Dhrystone MIPs/MHz. This parameter is not 100% tested but periodically sampled.
6. Typical power consumption for these modes is measured at the nominal recommended V_{DD} (see Table 4) and 105 °C in the mode described. This parameter is not 100% tested but is periodically sampled.

6 Pin Assignments

Figure 12 (in Part A) shows the pinout of the MPC7448, 360 high coefficient of thermal expansion ceramic ball grid array (HCTE) package as viewed from the top surface. Part B shows the side profile of the HCTE package to indicate the direction of the top surface view.

Part A



Part B

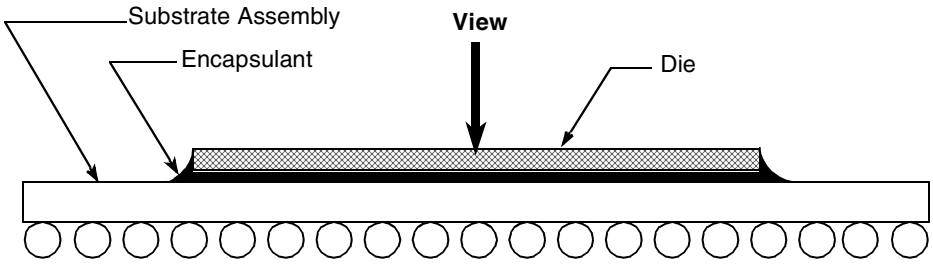


Figure 12. Pinout of the MPC7448, 360 HCTE Package as Viewed from the Top Surface

7 Pinout Listings

Table 11 provides the pinout listing for the MPC7448, 360 HCTE package. The pinouts of the MPC7448 and MPC7447A are compatible, but the requirements regarding the use of the additional power and ground pins have changed. The MPC7448 requires these pins be connected to the appropriate power or ground plane to achieve high core frequencies; see Section 9.3, “Connection Recommendations,” for additional information. As a result, these pins should be connected in all new designs.

Additionally, the MPC7448 may be populated on a board designed for a MPC7447 (or MPC7445 or MPC7441), provided the core voltage can be made to match the requirements in Table 4 and all pins defined as ‘no connect’ for the MPC7447 are unterminated, as required by the *MPC7457 RISC Microprocessor Hardware Specifications*. The MPC7448 uses pins previously marked ‘no connect’ for the temperature diode pins and for additional power and ground connections. The additional power and ground pins are required to achieve high core frequencies and core frequency will be limited if they are not connected; see Section 9.3, “Connection Recommendations,” for additional information. Because these ‘no connect’ pins in the MPC7447 360 pin package are not driven in functional mode, an MPC7447 can be populated in an MPC7448 board.

NOTE

Caution must be exercised when performing boundary scan test operations on a board designed for an MPC7448, but populated with an MPC7447 or earlier device. This is because in the MPC7447 it is possible to drive the latches associated with the former ‘no connect’ pins in the MPC7447, potentially causing contention on those pins. To prevent this, ensure that these pins are not connected on the board or, if they are connected, ensure that the states of internal MPC7447 latches do not cause these pins to be driven during board testing.

For the MPC7448, pins that were defined as the TEST[0:4] factory test signal group on the MPC7447A and earlier devices have been assigned new functions. For most of these, the termination recommendations for the TEST[0:4] pins of the MPC7447A are compatible with the MPC7448 and will allow correct operation with no performance loss. The exception is BVSEL1 (TEST3 on the MPC7447A and earlier devices), which may require a different termination depending which I/O voltage mode is desired; see Table 3 for more information.

NOTE

This pinout is not compatible with the MPC750, MPC7400, or MPC7410 360 BGA package.

8 Package Description

The following sections provide the package parameters and mechanical dimensions for the HCTE package.

8.1 Package Parameters for the MPC7448, 360 HCTE BGA

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

Package outline	25 × 25 mm
Interconnects	360 (19 × 19 ball array – 1)
Pitch	1.27 mm (50 mil)
Minimum module height	2.32 mm
Maximum module height	2.80 mm
Ball 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.

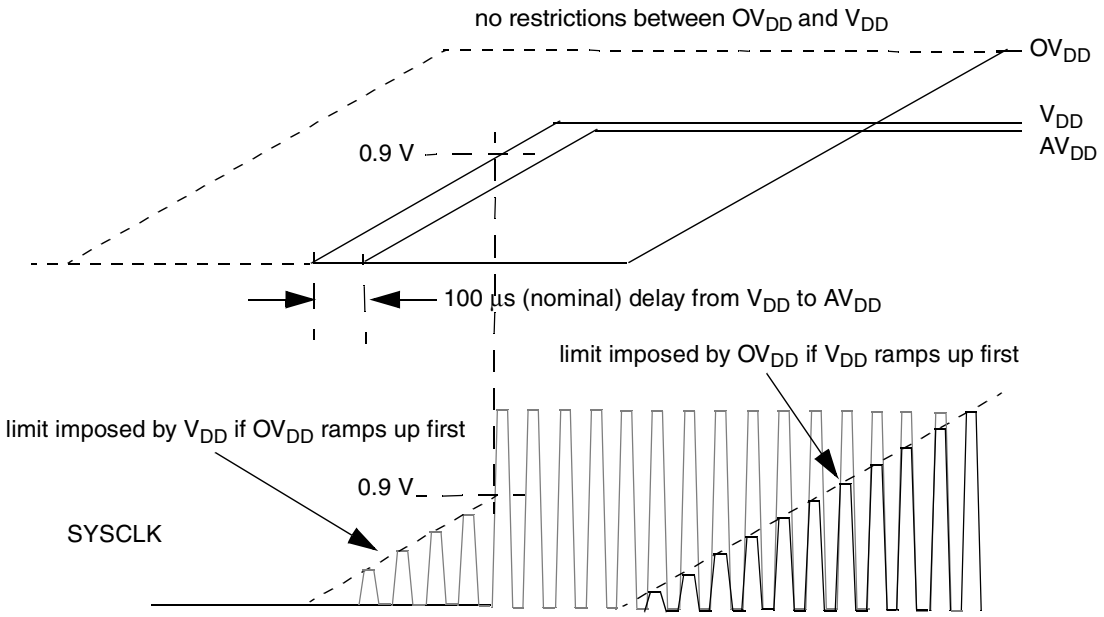


Figure 16. MPC7448 Power Up Sequencing Requirements

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.

9.2.3 Transient Specifications

The ensure the long-term reliability of the device, the MPC7448 requires that transients on the core power rail (V_{DD}) be constrained. The recommended operating voltage specifications provided in Table 4 are DC specifications. That is, the device may be operated continuously with V_{DD} within the specified range without adversely affecting the device's reliability. Excursions above the stated recommended operation range, including overshoot during power-up, can impact the long-term reliability of the device. Excursions are described by their amplitude and duration. Duration is defined as the time period during which the V_{DD} power plane, as measured at the VDD_SENSE pins, will be within a specific voltage range, expressed as percentage of the total time the device will be powered up over the device lifetime. In practice, the period over which transients are measured can be any arbitrary period of time that accurately represents the expected range of processor and system activity. The voltage ranges and durations for normal operation and transients are described in Table 14.

Table 14. VDD Power Supply Transient Specifications

At recommended operating temperatures. See Table 4.

Voltage Region	Voltage Range (V)		Permitted Duration [1]	Notes
	Min	Max		
Normal	V_{DD} minimum	V_{DD} maximum	100%	2
Low Transient	V_{DD} maximum	1.35 V	10%	2, 3
High Transient	1.35 V	1.40 V	0.2%	4

Notes:
1. Permitted duration is defined as the percentage of the total time the device is powered on that the V_{DD} power supply voltage may exist within the specified voltage range.
2. See Table 4 for nominal V_{DD} specifications.
3. To simplify measurement, excursions into the High Transient region are included in this duration.
4. Excursions above the absolute maximum rating of 1.4 V are not permitted; see Table 2.

Note that, to simplify transient measurements, the duration of the excursion into the High Transient region is also included in the Low Transient duration, so that only the time the voltage is above each threshold must be considered. Figure 19 shows an example of measuring voltage transients.

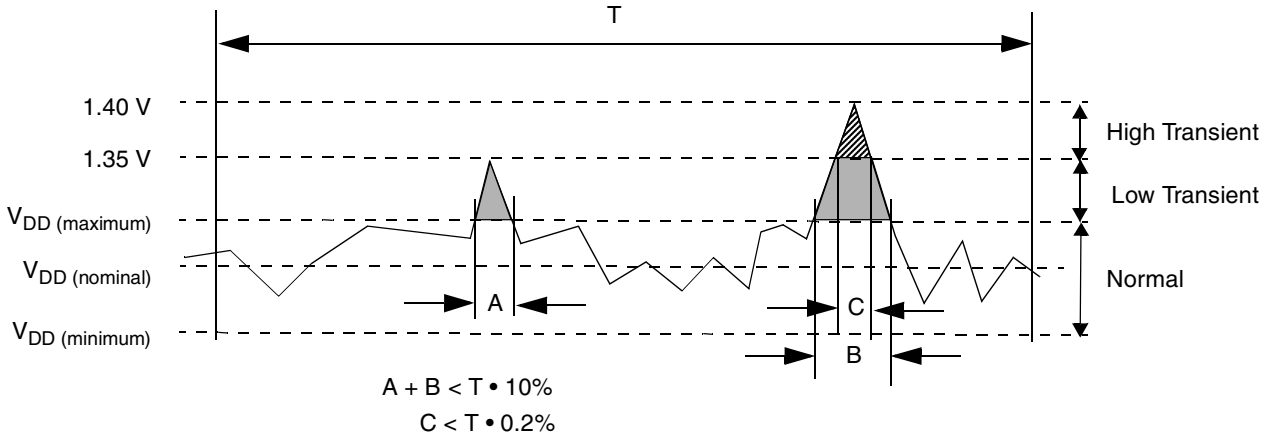


Figure 19. Voltage Transient Example

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 port to independently assert $\overline{\text{HRESET}}$ or $\overline{\text{TRST}}$, while ensuring that the target can drive $\overline{\text{HRESET}}$ as well. If the JTAG interface and COP header will not be used, $\overline{\text{TRST}}$ should be tied to $\overline{\text{HRESET}}$ through a 0-Ω isolation resistor so that it is asserted when the system reset signal ($\overline{\text{HRESET}}$) is asserted, ensuring that the JTAG scan chain is initialized during power-on. Although Freescale recommends that the COP header be designed into the system as shown in Figure 21, if this is not possible, the isolation resistor will allow future access to $\overline{\text{TRST}}$ in the case where a JTAG interface may need to be wired onto the system in debug situations.

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.

There is no standardized way to number the COP header shown in Figure 21; 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 1 (as with an IC). Regardless of the numbering, the signal placement recommended in Figure 21 is common to all known emulators.

The $\overline{\text{QACK}}$ signal shown in Figure 21 is usually connected to the bridge chip or other system control logic in a system and is an input to the MPC7448 informing it that it can go into the quiescent state. Under normal operation this occurs during a low-power mode selection. In order for COP to work, the MPC7448 must see this signal asserted (pulled down). While shown on the COP header, not all emulator products drive this signal. If the product does not, a pull-down resistor can be populated to assert this signal. Additionally, some emulator products implement open-drain type outputs and can only drive $\overline{\text{QACK}}$ asserted; for these tools, a pull-up resistor can be implemented to ensure this signal is negated when it is not being driven by the tool. Note that the pull-up and pull-down resistors on the $\overline{\text{QACK}}$ signal are mutually exclusive and it is never necessary to populate both in a system. To preserve correct power-down operation, $\overline{\text{QACK}}$ should be merged through logic so that it also can be driven by the bridge or system logic.

9.7.1 Internal Package Conduction Resistance

For the exposed-die packaging technology described in Table 5, the intrinsic conduction thermal resistance paths are as follows:

- The die junction-to-case thermal resistance (the case is actually the top of the exposed silicon die)
- The die junction-to-board thermal resistance

Figure 24 depicts the primary heat transfer path for a package with an attached heat sink mounted to a printed-circuit board.

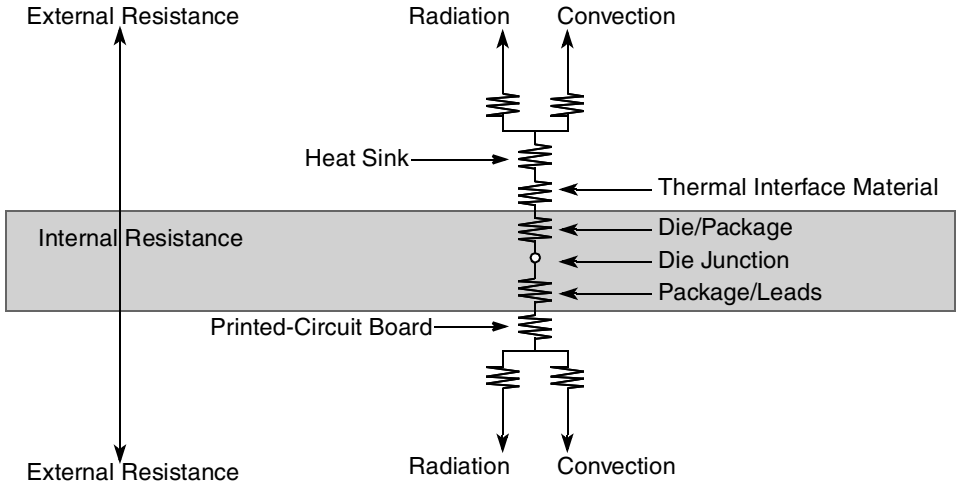


Figure 24. C4 Package with Heat Sink Mounted to a Printed-Circuit Board

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

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

9.7.2 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, fluoroether oil), a bare joint, and a joint with thermal grease as a function of contact pressure. As shown, the performance of these thermal interface materials improves with increasing contact pressure. The use of thermal grease significantly reduces the interface thermal resistance. That is, the bare joint results in a thermal resistance approximately seven times greater than the thermal grease joint.

Often, heat sinks are attached to the package by means of a spring clip to holes in the printed-circuit board (see Figure 22). Therefore, synthetic grease offers the best thermal performance due to the low interface pressure and is recommended due to the high power dissipation of the MPC7448. Of course, the selection

Shin-Etsu MicroSi, Inc. 10028 S. 51st St. Phoenix, AZ 85044 Internet: www.microsi.com	888-642-7674
Laird Technologies - Thermal (formerly Thermagon Inc.) 4707 Detroit Ave. Cleveland, OH 44102 Internet: www.lairdtech.com	888-246-905

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

9.7.3 Heat Sink Selection Example

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

$$T_j = T_i + T_r + (R_{\theta JC} + R_{\theta int} + R_{\theta sa}) \times P_d$$

where:

T_j is the die-junction temperature
T_i is the inlet cabinet ambient temperature
T_r is the air temperature rise within the computer cabinet
$R_{\theta JC}$ is the junction-to-case thermal resistance
$R_{\theta int}$ is the adhesive or interface material thermal resistance
$R_{\theta sa}$ is the heat sink base-to-ambient thermal resistance
P_d 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 4. The temperature of air cooling the component greatly depends on the ambient inlet air temperature and the air temperature rise within the electronic cabinet. An electronic cabinet inlet-air temperature (T_i) may range from 30□ to 40□C. The air temperature rise within a cabinet (T_r) may be in the range of 5□ to 10□C. The thermal resistance of the thermal interface material ($R_{\theta int}$) is typically about 1.1 □C/W. For example, assuming a T_i of 30□C, a T_r of 5□C, an HCTE package $R_{\theta JC}$ = 0.1, and a power consumption (P_d) of 25.6 W, the following expression for T_j is obtained:

Die-junction temperature: $T_j = 30□C + 5□C + (0.1□C/W + 1.1□C/W + \theta_{sa}) \times 25.6$

For this example, a $R_{\theta sa}$value of 1.53 □C/W or less is required to maintain the die junction temperature below the maximum value of Table 4.

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

Table 16. Valid Divide Ratio Configurations

DFS mode disabled		DFS divide-by-2 mode enabled (HID1[DFS2] = 1 or $\overline{\text{DFS2}}$ = 0)		DFS divide-by-4 mode enabled (HID1[DFS4] = 1 or $\overline{\text{DFS4}}$ = 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]

Table 17. Document Revision History (continued)

Revision	Date	Substantive Change(s)
2		Table 6: Added separate input leakage specification for BVSEL0, $\overline{\text{LSSD\_MODE}}$, $\overline{\text{TCK}}$, TDI, TMS, $\overline{\text{TRST}}$ signals to correctly indicate leakage current for signals with internal pull-up resistors. Section 5.1: Added paragraph preceding Table 7 and edited notes in Table 7 to clarify core frequencies at which power consumption is measured. Section 5.3: Removed voltage derating specifications; this feature has been made redundant by new device offerings and is no longer supported. Changed names of “Typical–Nominal” and “Typical–Thermal” power consumption parameters to “Typical” and “Thermal”, respectively. (Name change only–no specifications were changed.) Table 11: Revised Notes 16, 18, and 19 to reflect current recommendations for connection of SENSE pins. Section 9.3: Added paragraph explaining connection recommendations for SENSE pins. (See also Table 11 entry above.) Table 19: Updated table to reflect changes in specifications for MC7448xxnnnnNC devices. Table 9: Changed all instances of TT[0:3] to TT[0:4] Removed mention of these input signals from output valid times and output hold times: • AACK, CKSTP_IN, DT[0:3] Figure 17: Modified diagram slightly to correctly show constraint on SYSCLK ramping is related to V_{DD} voltage, not AV_{DD} voltage. (Diagram clarification only; no change in power sequencing requirements.) Added Table 20 to reflect introduction of extended temperature devices and associated hardware specification addendum.
1		Added 1600 MHz, 1420 MHz, and 1000 MHz devices Section 4: corrected die size Table 2: Revised Note 4 to consider overshoot/undershoot and combined with Note 5. Table 4: Revised operating voltage for 1700 MHz device from ± 50 mV to +20 mV / –50 mV. Table 7: Updated and expanded table to include Typical – Nominal power consumption. Table 11: Added voltage derating information for 1700 MHz devices; this feature is not supported at this time for other speed grades. Added transient specifications for VDD power supply in Section 9.2.3, added Table 15 and Figure 19 and renumbered subsequent tables and figures. Moved Decoupling Recommendations from Section 9.4 to Section 9.2.4 and renumbered subsequent sections. Section 9.2.1: Revised power sequencing requirements. Section 9.7.4: Added thermal diode ideality factor information (previously TBD). Table 17: Expanded table to show HID1 register values when DFS modes are enabled. Section 11.2: updated to include additional N-spec device speed grades Tables 18 and 19: corrected PVR values and added “MC” product code prefix
0		Initial public release.

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.