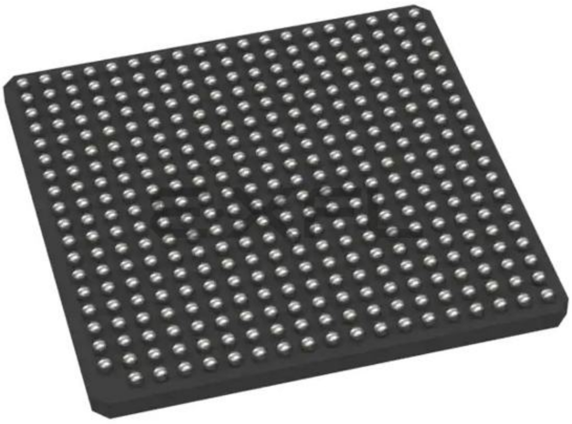

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Understanding Embedded - Microprocessors

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

Applications of Embedded - Microprocessors

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

Details	
Product Status	Obsolete
Core Processor	PowerPC G4
Number of Cores/Bus Width	1 Core, 32-Bit
Speed	1.7GHz
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/kmc7448vu1700ld

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

- Four vector units and 32-entry vector register file (VRs)
  - Vector permute unit (VPU)
  - Vector integer unit 1 (VIU1) handles short-latency AltiVec™ integer instructions, such as vector add instructions (for example, **vaddsbs**, **vaddshs**, and **vaddsws**).
  - Vector integer unit 2 (VIU2) handles longer-latency AltiVec integer instructions, such as vector multiply add instructions (for example, **vmhaddshs**, **vmhraddshs**, and **vmladduhm**).
  - Vector floating-point unit (VFPU)
- Three-stage load/store unit (LSU)
  - Supports integer, floating-point, and vector instruction load/store traffic
  - Four-entry vector touch queue (VTQ) supports all four architected AltiVec data stream operations
  - Three-cycle GPR and AltiVec load latency (byte, half word, word, vector) with one-cycle throughput
  - Four-cycle FPR load latency (single, double) with one-cycle throughput
  - No additional delay for misaligned access within double-word boundary
  - A dedicated adder calculates effective addresses (EAs).
  - Supports store gathering
  - Performs alignment, normalization, and precision conversion for floating-point data
  - Executes cache control and TLB instructions
  - Performs alignment, zero padding, and sign extension for integer data
  - Supports hits under misses (multiple outstanding misses)
  - Supports both big- and little-endian modes, including misaligned little-endian accesses

• Three issue queues, FIQ, VIQ, and GIQ, can accept as many as one, two, and three instructions, respectively, in a cycle. Instruction dispatch requires the following:
- Instructions can only be dispatched from the three lowest IQ entries—IQ0, IQ1, and IQ2.
- A maximum of three instructions can be dispatched to the issue queues per clock cycle.
- Space must be available in the CQ for an instruction to dispatch (this includes instructions that are assigned a space in the CQ but not in an issue queue).

• Rename buffers
- 16 GPR rename buffers
- 16 FPR rename buffers
- 16 VR rename buffers

• Dispatch unit
- Decode/dispatch stage fully decodes each instruction

• Completion unit
- Retires an instruction from the 16-entry completion queue (CQ) when all instructions ahead of it have been completed, the instruction has finished executing, and no exceptions are pending
- Guarantees sequential programming model (precise exception model)

Table 1. Microarchitecture Comparison (continued)

Microarchitectural Specs	MPC7448	MPC7447A	MPC7447	MPC7445	MPC7441
Execution Unit Timings (Latency-Throughput)					
Aligned load (integer, float, vector)	3-1, 4-1, 3-1				
Misaligned load (integer, float, vector)	4-2, 5-2, 4-2				
L1 miss, L2 hit latency with ECC (data/instruction)	12/16	—			
L1 miss, L2 hit latency without ECC (data/instruction)	11/15	9/13			
SFX (add, sub, shift, rot, cmp, logicals)	1-1				
Integer multiply (32×8, 32×16, 32×32)	4-1, 4-1, 5-2				
Scalar float	5-1				
VSFX (vector simple)	1-1				
VCFX (vector complex)	4-1				
VFPU (vector float)	4-1				
VPER (vector permute)	2-1				
MMUs					
TLBs (instruction and data)	128-entry, 2-way				
Tablewalk mechanism	Hardware + software				
Instruction BATs/data BATs	8/8	8/8	8/8	8/8	4/4
L1 I Cache/D Cache Features					
Size	32K/32K				
Associativity	8-way				
Locking granularity	Way				
Parity on I cache	Word				
Parity on D cache	Byte				
Number of D cache misses (load/store)	5/2	5/1			
Data stream touch engines	4 streams				
On-Chip Cache Features					
Cache level	L2				
Size/associativity	1-Mbyte/ 8-way	512-Kbyte/8-way		256-Kbyte/8-way	
Access width	256 bits				
Number of 32-byte sectors/line	2	2			
Parity tag	Byte	Byte			
Parity data	Byte	Byte			
Data ECC	64-bit	—			
Thermal Control					
Dynamic frequency switching divide-by-two mode	Yes	Yes	No	No	No
Dynamic frequency switching divide-by-four mode	Yes	No	No	No	No
Thermal diode	Yes	Yes	No	No	No

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.

5.2 AC Electrical Characteristics

This section provides the AC electrical characteristics for the MPC7448. After fabrication, functional parts are sorted by maximum processor core frequency as shown in Section 5.2.1, “Clock AC Specifications,” and tested for conformance to the AC specifications for that frequency. The processor core frequency, determined by the bus (SYSCLK) frequency and the settings of the PLL_CFG[0:5] signals, can be dynamically modified using dynamic frequency switching (DFS). Parts are sold by maximum processor core frequency; see Section 11, “Part Numbering and Marking,” for information on ordering parts. DFS is described in Section 9.7.5, “Dynamic Frequency Switching (DFS).”

5.2.1 Clock AC Specifications

Table 8 provides the clock AC timing specifications as defined in Figure 3 and represents the tested operating frequencies of the devices. The maximum system bus frequency, f_{SYSCLK}, given in Table 8, is considered a practical maximum in a typical single-processor system. This does not exclude multi-processor systems, but these typically require considerably more design effort to achieve the maximum rated bus frequency. The actual maximum SYSCLK frequency for any application of the MPC7448 will be a function of the AC timings of the microprocessor(s), the AC timings for the system controller, bus loading, circuit board topology, trace lengths, and so forth, and may be less than the value given in Table 8.

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 $\overline{TS}$, $\overline{ARTRY}$, $\overline{SHD0}$, $\overline{SHD1}$)	t_{KHOZ}	—	1.8	ns	5
SYSCLK to $\overline{TS}$ high impedance after precharge	t_{KHTSPZ}	—	1	t_{SYSCLK}	3, 4, 5
Maximum delay to $\overline{ARTRY}$/$\overline{SHD0}$/$\overline{SHD1}$ precharge	t_{KHARP}	—	1	t_{SYSCLK}	3, 5, 6, 7
SYSCLK to $\overline{ARTRY}$/$\overline{SHD0}$/$\overline{SHD1}$ 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, $\overline{TS}$ 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 $\overline{TS}$ is t_{SYSCLK}, that is, one clock period. Since no master can assert $\overline{TS}$ 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, $\overline{ARTRY}$ can be driven by multiple bus masters through the clock period immediately following $\overline{AACK}$. Bus contention is not an issue because 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 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 $\overline{ARTRY}$ 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 $\overline{ARTRY}$. 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, $\overline{SHD0}$ and $\overline{SHD1}$ can be driven by multiple bus masters beginning two cycles after $\overline{TS}$. Timing is the same as $\overline{ARTRY}$, 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 $\overline{SHD0}$ and $\overline{SHD1}$ is 1.0 t_{SYSCLK}. The edges of the precharge vary depending on the programmed ratio of core to bus (PLL configurations).
8. $\overline{BMODE}$[0:1] and BVSEL[0:1] are mode select inputs. $\overline{BMODE}$[0:1] are sampled before and after $\overline{HRESET}$ negation. BVSEL[0:1] are sampled before $\overline{HRESET}$ negation. These parameters represent the input setup and hold times for each sample. These values are guaranteed by design and not tested. $\overline{BMODE}$[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 4 provides the AC test load for the MPC7448.

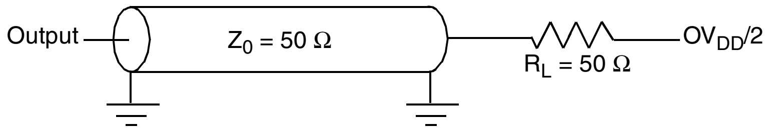


Figure 4. AC Test Load

Figure 5 provides the $\overline{\text{BMODE}}$[0:1] input timing diagram for the MPC7448. These mode select inputs are sampled once before and once after $\overline{\text{HRESET}}$ negation.

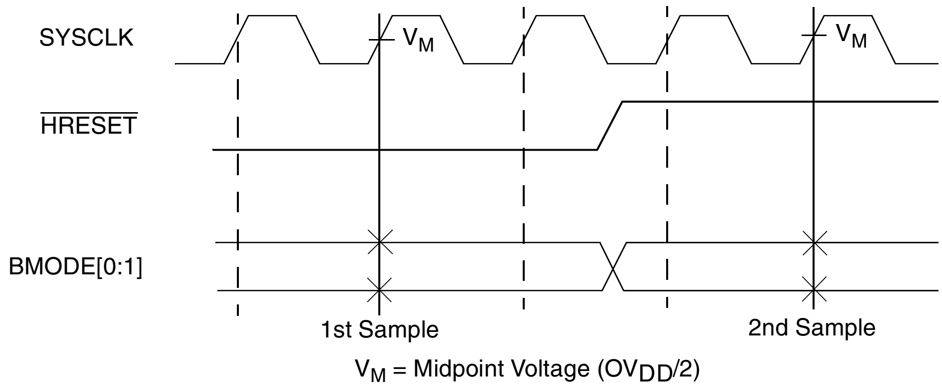


Figure 5. $\overline{\text{BMODE}}$[0:1] Input Sample Timing Diagram

5.2.3 IEEE Std. 1149.1 AC Timing Specifications

Table 10 provides the IEEE Std. 1149.1 (JTAG) AC timing specifications as defined in Figure 8 through Figure 11.

Table 10. JTAG AC Timing Specifications (Independent of SYSCLK)[1]

At recommended operating conditions. See Table 4.

Parameter	Symbol	Min	Max	Unit	Notes
TCK frequency of operation	f_{TCLK}	0	33.3	MHz	
TCK cycle time	t_{TCLK}	30	—	ns	
TCK clock pulse width measured at 1.4 V	t_{JHJL}	15	—	ns	
TCK rise and fall times	t_{JR} and t_{JF}	—	2	ns	
$\overline{\text{TRST}}$ assert time	t_{TRST}	25	—	ns	2
Input setup times: Boundary-scan data TMS, TDI	 t_{DVJH} t_{IVJH}	 4 0	 — —	ns	3
Input hold times: Boundary-scan data TMS, TDI	 t_{DXJH} t_{IXJH}	 20 25	 — —	ns	3
Valid times: Boundary-scan data TDO	 t_{JLDV} t_{JLOV}	 4 4	 20 25	ns	4
Output hold times: Boundary-scan data TDO	 t_{JLDX} t_{JLOX}	 30 30	 — —	ns	4
TCK to output high impedance: Boundary-scan data TDO	 t_{JLDZ} t_{JLOZ}	 3 3	 19 9	ns	4, 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-Ω load (see Figure 7). Time-of-flight delays must be added for trace lengths, vias, and connectors in the system.
2. $\overline{\text{TRST}}$ is an asynchronous level sensitive signal. The 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 test access port timing diagram.

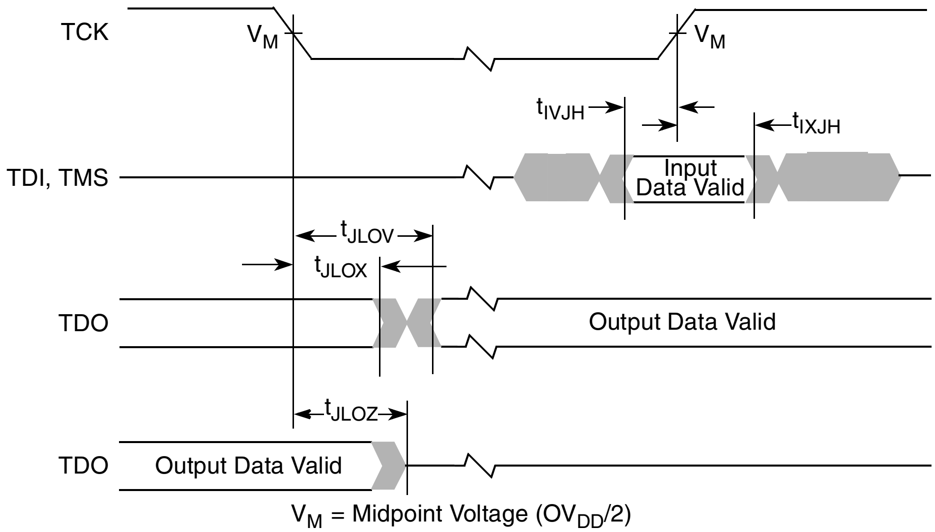


Figure 11. Test Access Port Timing Diagram

5.3 Voltage and Frequency Derating

Voltage and frequency derating is no longer supported for part numbers described by this document beginning with datecode 0613. (See Section 11, "Part Numbering and Marking," for information on date code markings.) It is supported by some MPC7448 part numbers which target low-power applications; see Section 11.2, "Part Numbers Not Fully Addressed by This Document" and the referenced MPC7448 Hardware Specification Addenda for more information on these low-power devices. For those devices which previously supported this feature, information has been archived in the *Chip Errata for the MPC7448* (document order no. MPC7448CE).

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 Package Description

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

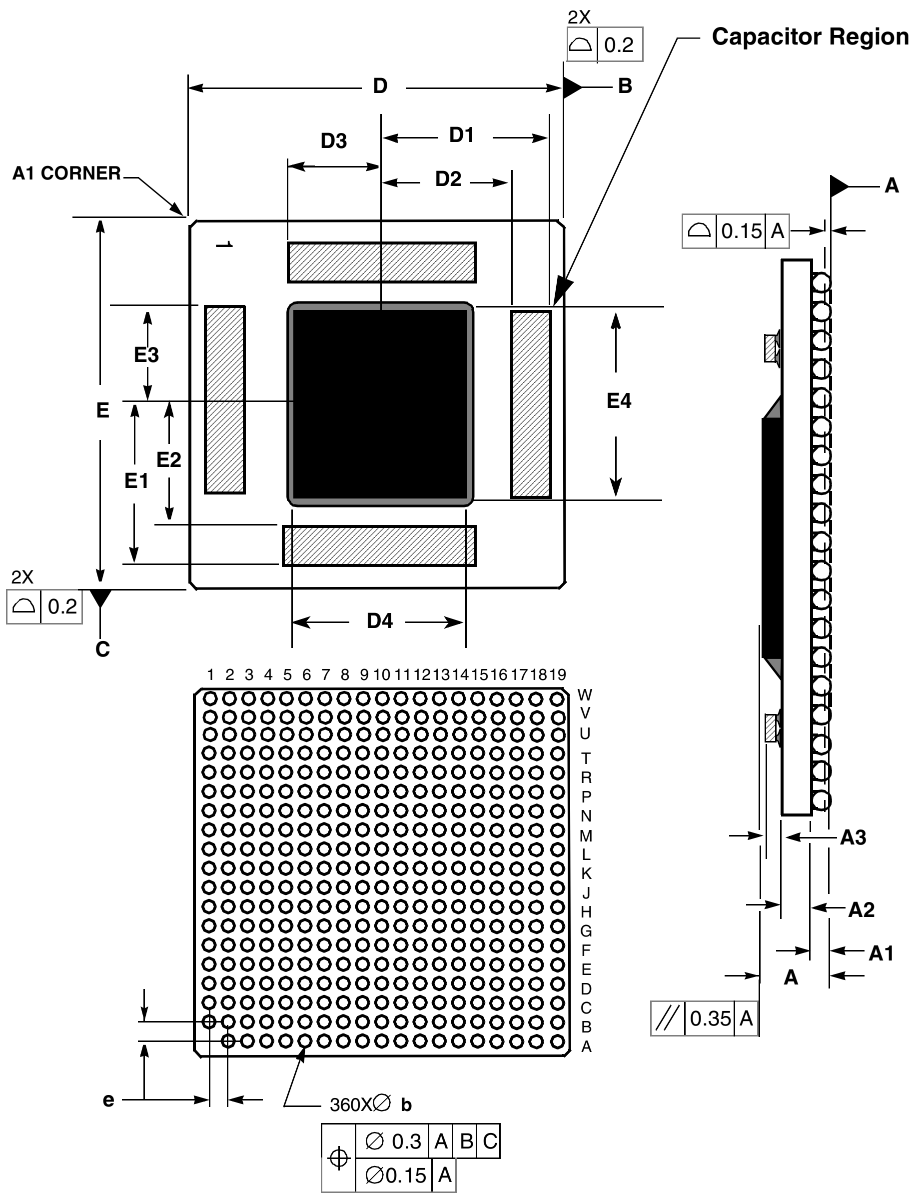
8.1 Package Parameters for the MPC7448, 360 HCTE BGA

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

8.2 Mechanical Dimensions for the MPC7448, 360 HCTE BGA

Figure 13 provides the mechanical dimensions and bottom surface nomenclature for the MPC7448, 360 HCTE BGA package.



NOTES:
1. Dimensioning and tolerancing per ASME Y14.5M, 1994
2. Dimensions in millimeters.
3. Top side A1 corner index is a metalized feature with various shapes. Bottom side A1 corner is designated with a ball missing from the array.

	Millimeters	
Dim	**Min**	**Max**
A	2.32	2.80
A1	0.80	1.00
A2	0.70	0.90
A3	—	0.6
b	0.82	0.93
D	25.00 BSC	
D1	—	11.3
D2	8.0	—
D3	—	6.5
D4	7.2	7.4
e	1.27 BSC	
E	25.00 BSC	
E1	—	11.3
E2	8.0	—
E3	—	6.5
E4	7.9	8.1

Figure 13. Mechanical Dimensions and Bottom Surface Nomenclature for the MPC7448, 360 HCTE BGA Package

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.

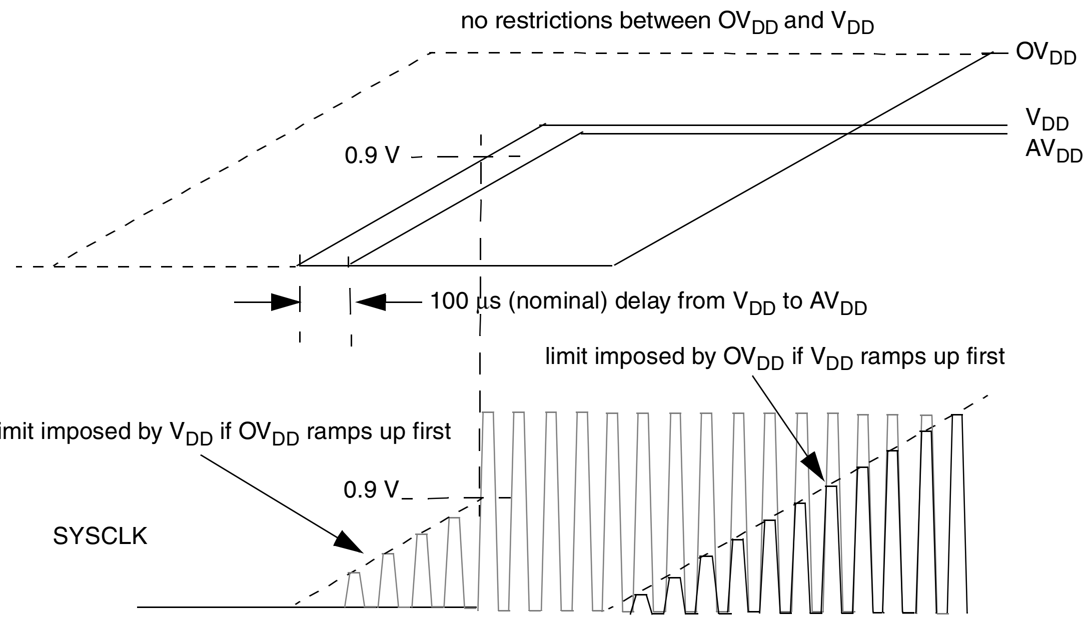


Figure 16. MPC7448 Power Up Sequencing Requirements

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.

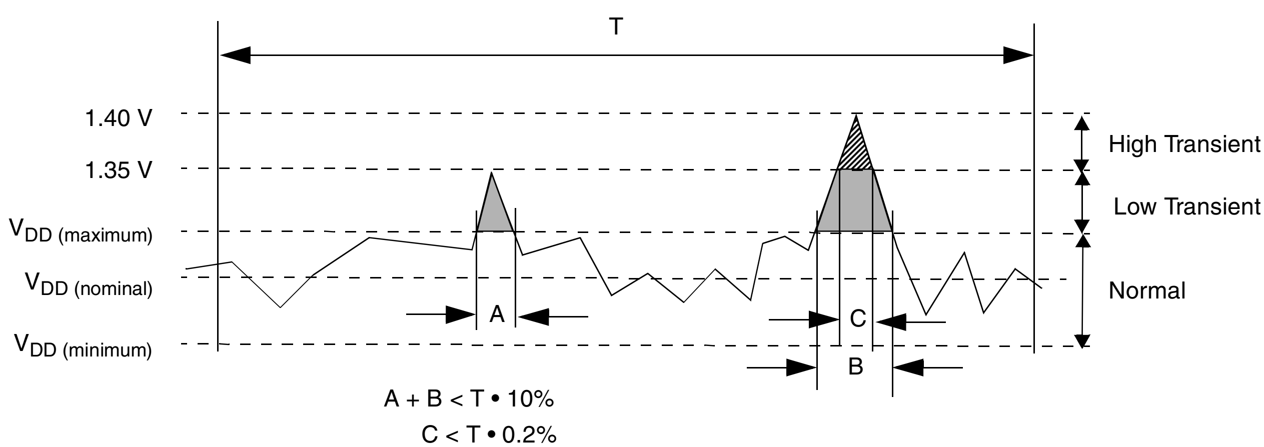


Figure 19. Voltage Transient Example

likewise be pulled up through a pull-up resistor (weak or stronger: 4.7–1 KΩ) to prevent erroneous assertions of this signal.

In addition, the MPC7448 has one open-drain style output that requires a pull-up resistor (weak or stronger: 4.7–1 KΩ) if it is used by the system. This pin is $\overline{\text{CKSTP\_OUT}}$.

BVSEL0 and BVSEL1 should not be allowed to float, and should be configured either via pull-up or pull-down resistors or actively driven by external logic. If pull-down resistors are used to configure BVSEL0 or BVSEL1, the resistors should be less than 250 Ω (see Table 11). Because PLL_CFG[0:5] must remain stable during normal operation, strong pull-up and pull-down resistors (1 KΩ or less) are recommended to configure these signals in order to protect against erroneous switching due to ground bounce, power supply noise, or noise coupling.

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. Because the MPC7448 must continually monitor these signals for snooping, this float condition may cause excessive power draw by the input receivers on the MPC7448 or by other receivers in the system. These signals can be pulled up through weak (10-KΩ) pull-up resistors by the system, address bus driven mode enabled (see the *MPC7450 RISC Microprocessor Family Users' Manual* for more information on this mode), or they may be otherwise driven by the system during inactive periods of the bus to avoid this additional power draw. Preliminary studies have shown the additional power draw by the MPC7448 input receivers to be negligible and, in any event, none of these measures are necessary for proper device operation. The snooped address and transfer attribute inputs are: A[0:35], AP[0:4], TT[0:4], $\overline{\text{CI}}$, $\overline{\text{WT}}$, and $\overline{\text{GBL}}$.

If address or data parity is not used by the system, and respective parity checking is disabled through HID1, the input receivers for those pins are disabled and do not require pull-up resistors, therefore they may be left unconnected by the system. If extended addressing is not used (HID0[XAEN] = 0), A[0:3] are unused and must be pulled low to GND through weak pull-down resistors; additionally, if address parity checking is enabled (HID1[EBA] = 1) and extended addressing is not used, AP[0] must be pulled up to OV_{DD} through a weak pull-up resistor. If the MPC7448 is in 60x bus mode, DTI[0:3] must be pulled low to GND through weak pull-down resistors.

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 pull-ups or require that those signals be otherwise driven by the system during inactive periods. The data bus signals are D[0:63] and DP[0:7].

9.6 JTAG Configuration Signals

Boundary-scan testing is enabled through the JTAG interface signals. The $\overline{\text{TRST}}$ signal is optional in the IEEE 1149.1 standard specification, but is typically provided on all processors that implement the PowerPC architecture. 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 $\overline{\text{TRST}}$ signal is asserted during power-on reset. Because the JTAG interface is also used for accessing the common on-chip processor (COP) function, simply tying $\overline{\text{TRST}}$ to $\overline{\text{HRESET}}$ is not practical.

The COP function of these 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 $\overline{\text{HRESET}}$ or $\overline{\text{TRST}}$ in order

Due to the complexity and variety 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.

For system thermal modeling, the MPC7448 thermal model is shown in Figure 26. Four volumes represent this device. Two of the volumes, solder ball-air and substrate, are modeled using the package outline size of the package. The other two, die and bump-underfill, have the same size as the die. The silicon die should be modeled $8.0 \times 7.3 \times 0.86\ mm^3$ with the heat source applied as a uniform source at the bottom of the volume. The bump and underfill layer is modeled as $8.0 \times 7.3 \times 0.07\ mm^3$ collapsed in the z-direction with a thermal conductivity of 5.0 W/(m • K) in the z-direction. The substrate volume is $25 \times 25 \times 1.14\ mm^3$ and has 9.9 W/(m • K) isotropic conductivity in the xy-plane and 2.95 W/(m • K) in the direction of the z-axis. The solder ball and air layer are modeled with the same horizontal dimensions as the substrate and is 0.8 mm thick. For the LGA package the solder and air layer is 0.1 mm thick, but the material properties are the same. It can also be modeled as a collapsed volume using orthotropic material properties: 0.034 W/(m • K) in the xy-plane direction and 11.2 W/(m • K) in the direction of the z-axis.

Conductivity	Value	Unit
Die ($8.0 \times 7.3 \times 0.86\ mm^3$)		
Silicon	Temperature-dependent	W/(m • K)
Bump and Underfill ($8.0 \times 7.3 \times 0.07\ mm^3$)		
k_z	5.0	W/(m • K)
Substrate ($25 \times 25 \times 1.14\ mm^3$)		
k_x	9.9	W/(m • K)
k_y	9.9	
k_z	2.95	
Solder Ball and Air ($25 \times 25 \times 0.8\ mm^3$)		
k_x	0.034	W/(m • K)
k_y	0.034	
k_z	11.2	

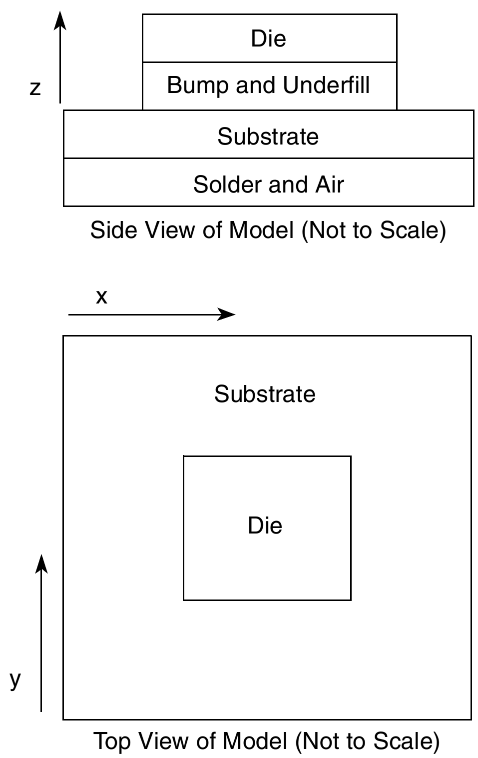


Figure 26. Recommended Thermal Model of MPC7448

Solving for T, the equation becomes:

$$nT = \frac{V_H - V_L}{1.986 \times 10^{-4}}$$

9.7.5 Dynamic Frequency Switching (DFS)

The DFS feature in the MPC7448 adds the ability to divide the processor-to-system bus ratio by two or four during normal functional operation. Divide-by-two mode is enabled by setting the HID1[DFS2] bit in software or by asserting the $\overline{\text{DFS2}}$ pin via hardware. The MPC7448 can be returned for full speed by clearing HID1[DFS2] or negating $\overline{\text{DFS2}}$. Similarly, divide-by-four mode is enabled by setting HID1[DFS4] in software or by asserting the $\overline{\text{DFS4}}$ pin. In all cases, the frequency change occurs in 1 clock cycle and no idle waiting period is required to switch between modes. Note that asserting either $\overline{\text{DFS2}}$ or $\overline{\text{DFS4}}$ overrides software control of DFS, and that asserting both $\overline{\text{DFS2}}$ and $\overline{\text{DFS4}}$ disables DFS completely, including software control. Additional information regarding DFS can be found in the *MPC7450 RISC Microprocessor Family Reference Manual*. Note that minimum core frequency requirements must be observed when enabling DFS, and the resulting core frequency must meet the requirements for f_{core_DFS} given in Table 8.

9.7.5.1 Power Consumption with DFS Enabled

Power consumption with DFS enabled can be approximated using the following formula:

$$\mathbf{P_{DFS}} = \left[\frac{f_{DFS}}{f}\,(P - P_{DS})\right] + P_{DS}$$

Where:

P_{DFS} = Power consumption with DFS enabled

f_{DFS} = Core frequency with DFS enabled

f = Core frequency prior to enabling DFS

P = Power consumption prior to enabling DFS (see Table 7)

P_{DS} = Deep sleep mode power consumption (see Table 7)

The above is an approximation only. Power consumption with DFS enabled is not tested or guaranteed.

9.7.5.2 Bus-to-Core Multiplier Constraints with DFS

DFS is not available for all bus-to-core multipliers as configured by PLL_CFG[0:5] during hard reset. The complete listing is shown in Table 16. Shaded cells represent DFS modes that are not available for a particular PLL_CFG[0:5] setting. Should software or hardware attempt to transition to a multiplier that is not supported, the device will remain at its current multiplier. For example, if a transition from DFS-disabled to an unsupported divide-by-2 or divide-by-4 setting is attempted, the bus-to-core multiplier will remain at the setting configured by the PLL_CFG[0:5] pins. In the case of an attempted transition from a supported divide-by-2 mode to an unsupported divide-by-4 mode, the device will remain in divide-by-2 mode. In all cases, the HID1[PC0-5] bits will correctly reflect the current bus-to-core frequency multiplier.

11.2 Part Numbers Not Fully Addressed by This Document

Parts with application modifiers or revision levels not fully addressed in this specification document are described in separate hardware specification addenda which supplement and supersede this document. As such parts are released, these specifications will be listed in this section.

Table 19. Part Numbers Addressed by MC7448*xxnnnn*N*x* Series Hardware Specification Addendum (Document Order No. MPC7448ECS01AD)

xx	7448	*xx*	*nnnn*	N	*x*
Product Code	**Part Identifier**	**Package**	**Processor Frequency**	**Application Modifier**	**Revision Level**
MC	7448	HX = HCTE BGA VS = RoHS LGA VU = RoHS BGA	1400	N: 1.15 V ± 50 mV 0 to 105 °C (date code 0613 and later) [2]	C: 2.1; PVR = 0x8004_0201 D: 2.2; PVR = 0x8004_0202
MC PPC[1]			1400	N: 1.1 V ± 50 mV 0 to 105 °C (date code 0612 and prior) [2]	
MC PPC[1]			1267 Revision C only	N: 1.1 V ± 50 mV 0 to 105 °C	
MC PPC[1]			1267 Revision D only	N: 1.05 V ± 50 mV 0 to 105 °C	
MC PPC[1]			1250	N: 1.1 V ± 50 mV 0 to 105 °C	
MC PPC[1]			1000 867 800 667 600	N: 1.0 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 can 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.
2. Core voltage for 1400 MHz devices currently in production (date code of 0613 and later) is 1.15 V ± 50 mV; all such devices have the MC product code. The 1400 MHz devices with date code of 0612 and prior specified core voltage of 1.1 V ± 50 mV; this includes all 1400 MHz devices with the PPC product code. See Section 11.3, “Part Marking,” for information on part marking.

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