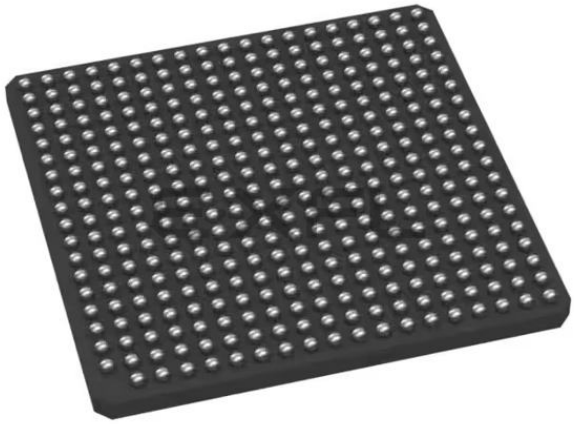

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Understanding Embedded - Microprocessors

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	1.25GHz
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-CLGA, FCCLGA
Supplier Device Package	360-FCCLGA (25x25)
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/mc7448vs1250nc

- 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 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 6. DC Electrical Specifications (continued)

At recommended operating conditions. See Table 4.

Characteristic		Nominal Bus Voltage [1]	Symbol	Min	Max	Unit	Notes
High-impedance (off-state) leakage current: $V_{in} = OV_{DD}$ V_{in} = GND		—	I_{TSI}	—	 50 – 50	µA	2, 3, 4
Output high voltage @ I_{OH} = –5 mA		1.5	V_{OH}	OV_{DD} – 0.45	—	V	
		1.8		OV_{DD} – 0.45	—		
		2.5		1.8	—		
Output low voltage @ I_{OL} = 5 mA		1.5	V_{OL}	—	0.45	V	
		1.8		—	0.45		
		2.5		—	0.6		
Capacitance, V_{in} = 0 V, f = 1 MHz	All inputs		C_{in}	—	8.0	pF	5

Notes:

1. Nominal voltages; see Table 4 for recommended operating conditions.
2. All I/O signals are referenced to OV_{DD}.
3. Excludes test signals and IEEE Std. 1149.1 boundary scan (JTAG) signals
4. The leakage is measured for nominal OV_{DD} and V_{DD}, or both OV_{DD} and V_{DD} must vary in the same direction (for example, both OV_{DD} and V_{DD} vary by either +5% or –5%).
5. Capacitance is periodically sampled rather than 100% tested.
6. These pins have internal pull-up resistors.

Table 7 provides the power consumption for the MPC7448 part numbers described by this document; see Section 11.1, “Part Numbers Fully Addressed by This Document,” for information regarding which part numbers are described by this document. Freescale also offers MPC7448 part numbers that meet lower power consumption specifications by adhering to lower core voltage and core frequency specifications. For more information on these devices, including references to the MPC7448 Hardware Specification Addenda that describe these devices, see Section 11.2, “Part Numbers Not Fully Addressed by This Document.”

The power consumptions provided in Table 7 represent the power consumption of each speed grade when operated at the rated maximum core frequency (see Table 8). Freescale sorts devices by power as well as by core frequency, and power limits for each speed grade are independent of each other. Each device is tested at its maximum core frequency only. (Note that Deep Sleep Mode power consumption is independent of clock frequency.) Operating a device at a frequency lower than its rated maximum is fully supported provided the clock frequencies are within the specifications given in Table 8, and a device operated below its rated maximum will have lower power consumption. However, inferences should not be made about a device’s power consumption based on the power specifications of another (lower) speed grade. For example, a 1700 MHz device operated at 1420 MHz may not exhibit the same power consumption as a 1420 MHz device operated at 1420 MHz.

For all MPC7448 devices, the following guidelines on the use of these parameters for system design are suggested. The Full-Power Mode–Typical value represents the sustained power consumption of the device

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 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 $\overline{\text{HRESET}}$ 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.

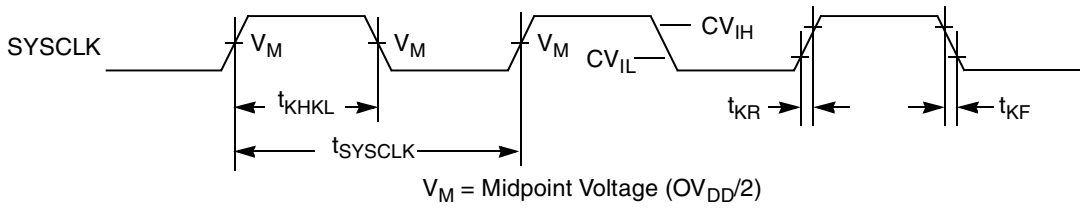


Figure 3. SYSCLK Input Timing Diagram

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		Unit	Notes
		Min	Max		
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 $\overline{TS}$, $\overline{ARTRY}$, $\overline{SHD0}$, $\overline{SHD1}$)	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.

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.

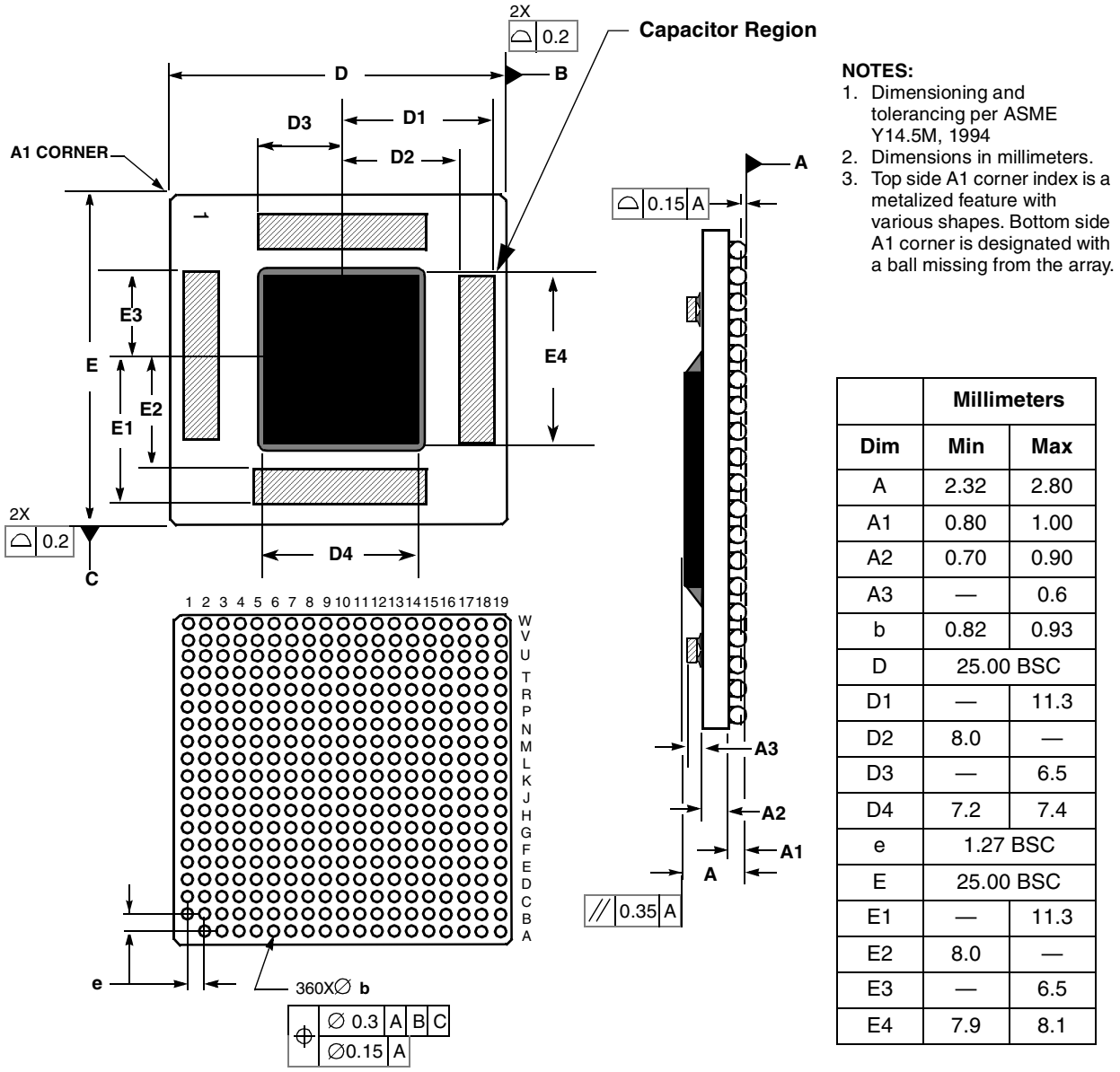
8.1 Package Parameters for the MPC7448, 360 HCTE BGA

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

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.



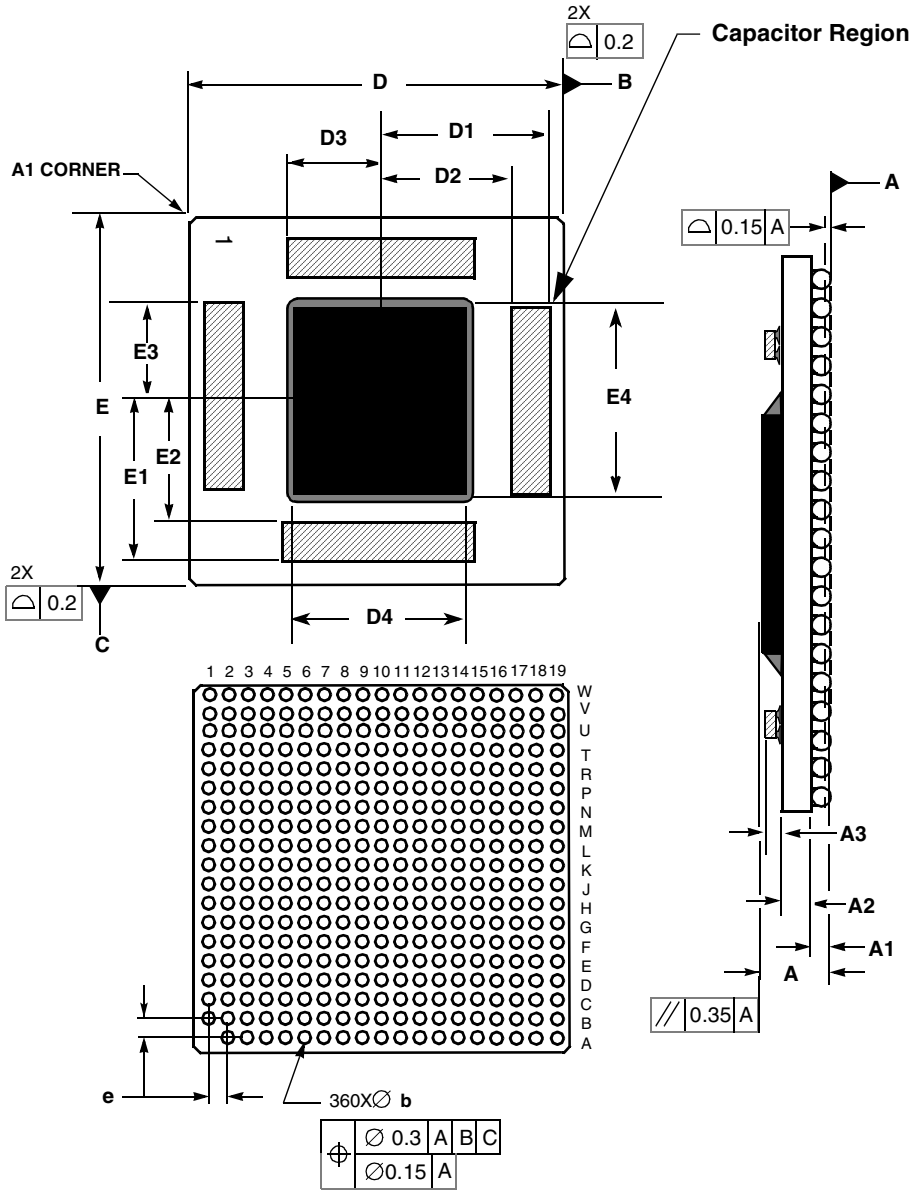
NOTES:
1. Dimensioning and tolerancing per ASME Y14.5M, 1994
2. Dimensions in millimeters.
3. Top side A1 corner index is a metalized feature with various shapes. Bottom side A1 corner is designated with a ball missing from the array.

	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

8.6 Mechanical Dimensions for the MPC7448, 360 HCTE RoHS-Compliant BGA

Figure 13 provides the mechanical dimensions and bottom surface nomenclature for the MPC7448, 360 HCTE BGA package with RoHS-compliant lead-free spheres.



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.
4. Dimension A1 represents the collapsed sphere diameter.

	Millimeters	
Dim	**Min**	**Max**
A	1.92	2.40
A1 [4]	0.40	0.60
A2	0.70	0.90
A3	—	0.6
b	0.60	0.90
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 15. Mechanical Dimensions and Bottom Surface Nomenclature for the MPC7448, 360 HCTE RoHS-Compliant 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.

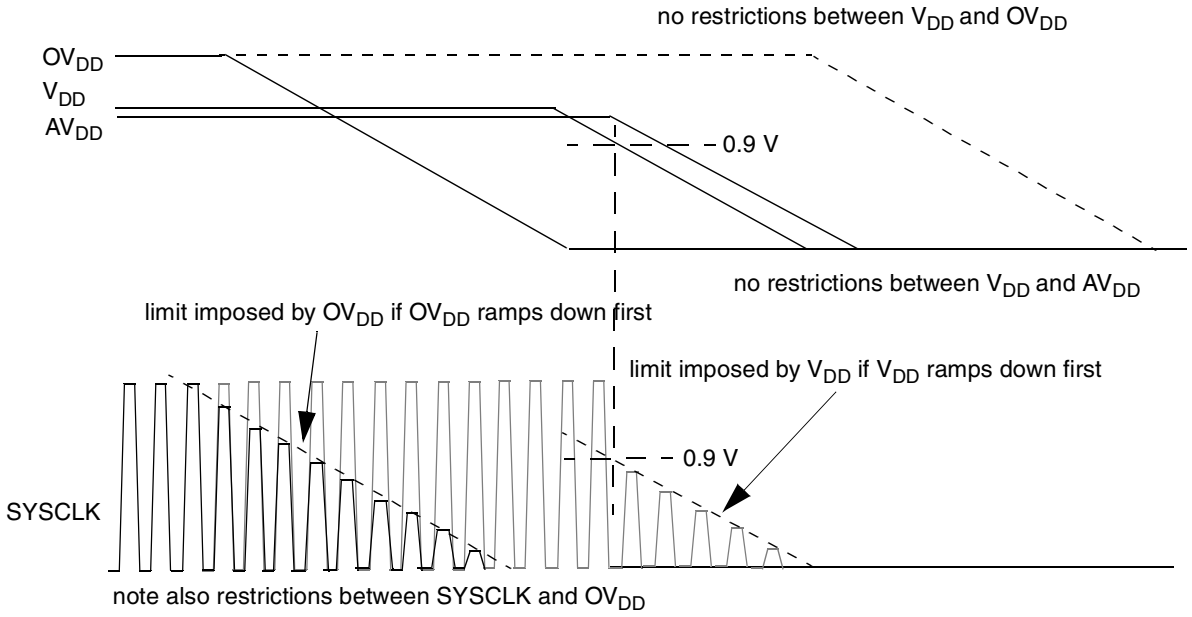


Figure 17. MPC7448 Power Down Sequencing Requirements

There is no requirement regarding AV_{DD} during power down, but it is recommended that AV_{DD} track V_{DD} within the RC time constant of the PLL filter circuit described in Section 9.2.2, "PLL Power Supply Filtering" (nominally 100 µs).

9.2.2 PLL Power Supply Filtering

The AV_{DD} power signal is provided on the MPC7448 to provide power to the clock generation PLL. To ensure stability of the internal clock, the power supplied to the AV_{DD} input signal should be filtered of any noise in the 500-KHz to 10-MHz resonant frequency range of the PLL. The circuit shown in Figure 18 using surface mount capacitors with minimum effective series inductance (ESL) is strongly recommended. In addition to filtering noise from the AV_{DD} input, it also provides the required delay between V_{DD} and AV_{DD} as described in Section 9.2.1, "Power Supply Sequencing."

The circuit should be placed as close as possible to the AV_{DD} pin to minimize noise coupled from nearby circuits. It is often possible to route directly from the capacitors to the AV_{DD} pin, which is on the periphery of the device footprint.

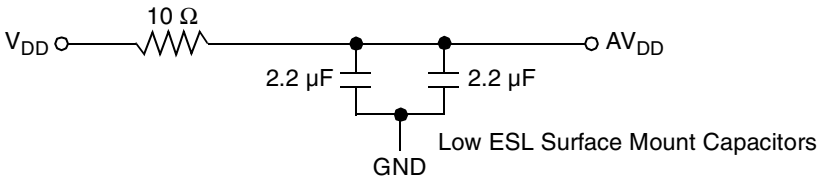


Figure 18. PLL Power Supply Filter Circuit

9.4 Output Buffer DC Impedance

The MPC7448 processor bus drivers are characterized over process, voltage, and temperature. To measure Z_0, an external resistor is connected from the chip pad to OV_{DD} or GND. The value of each resistor is varied until the pad voltage is $OV_{DD}/2$. Figure 20 shows the driver impedance measurement.

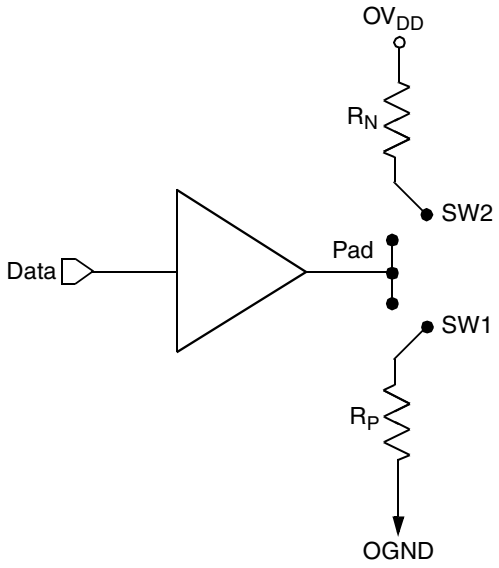


Figure 20. Driver Impedance Measurement

The output impedance is the average of two components—the resistances of the pull-up and pull-down devices. When data is held low, SW2 is closed (SW1 is open), and R_N is trimmed until the voltage at the pad equals $OV_{DD}/2$. R_N then becomes the resistance of the pull-down devices. When data is held high, SW1 is closed (SW2 is open), and R_P is trimmed until the voltage at the pad equals $OV_{DD}/2$. R_P then becomes the resistance of the pull-up devices. R_P and R_N are designed to be close to each other in value. Then, $Z_0 = (R_P + R_N)/2$.

Table 15 summarizes the signal impedance results. The impedance increases with junction temperature and is relatively unaffected by bus voltage.

Table 15. Impedance Characteristics

At recommended operating conditions. See Table 4

Impedance		Processor Bus	Unit
Z_0	Typical	33–42	Ω
	Maximum	31–51	Ω

9.5 Pull-Up/Pull-Down Resistor Requirements

The MPC7448 requires high-resistive (weak: 4.7-KΩ) pull-up resistors on several control pins of the bus interface to maintain the control signals in the negated state after they have been actively negated and released by the MPC7448 or other bus masters. These pins are: $\overline{TS}$, $\overline{ARTRY}$, $\overline{SHDO}$, and $\overline{SHD1}$.

Some pins designated as being factory test pins must be pulled up to OV_{DD} or down to GND to ensure proper device operation. The pins that must be pulled up to OV_{DD} are $\overline{LSSD\_MODE}$ and TEST[0:3]; the pins that must be pulled down to GND are L1_TSTCLK and TEST[4]. The $\overline{CKSTP\_IN}$ signal should

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 16. Valid Divide Ratio Configurations (continued)

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]
24x	011010	12x	101110	6x	110100
28x	111010	14x	110010	7x	001000

Notes:
1. DFS mode is not supported for this combination of DFS mode and PLL_CFG[0:5] setting. As a result, the processor will ignore these settings and remain at the previous multiplier, as reflected by the HID1[PC0-PC5] bits.
2. Though supported by the MPC7448 clock circuitry, multipliers of *n*.25x and *n*.75x cannot be expressed as valid PLL configuration codes. As a result, the values displayed in HID1[PC0-PC5] are rounded down to the nearest valid PLL configuration code. However, the actual bus-to-core multiplier is as stated in this table.
3. Note that in the HID1 register of the MPC7448, the PC0, PC1, PC2, PC3, PC4, and PC5 bits are bits 15, 16, 17, 18, 19, and 14 (respectively). See the *MPC7450 RISC Microprocessor Reference Manual* for more information.
4. Special considerations regarding snooped transactions must be observed for bus-to-core multipliers less than 5x. See the *MPC7450 RISC Microprocessor Reference Manual* for more information.

9.7.5.3 Minimum Core Frequency Requirements with DFS

In many systems, enabling DFS can result in very low processor core frequencies. However, care must be taken to ensure that the resulting processor core frequency is within the limits specified in Table 8. Proper operation of the device is not guaranteed at core frequencies below the specified minimum f_{core}.

10 Document Revision History

Table 17 provides a revision history for this hardware specification.

Table 17. Document Revision History

Revision	Date	Substantive Change(s)
4	3/2007	Table 19: Added 800 MHz processor frequency.
3	10/2006	Section 9.7, “Power and Thermal Management Information”: Updated contact information. Table 18, Table 20, and Table 19: Added Revision D PVR. Table 19: Added 600 processor frequency, additional product codes, date codes for 1400 processor frequency, and footnotes 1 and 2. Table 20: Added PPC product code and footnote 1. Table 19 and Table 20: Added Revision D information for 1267 processor frequency.

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.

11.2 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.

Table 20. Part Numbers Addressed by MC7448T*xxnnnn*N*x* Series Hardware Specification Addendum (Document Order No. MPC7448ECS02AD)

xx	**7448**	**T**	***xx***	***nnnn***	**N**	***x***

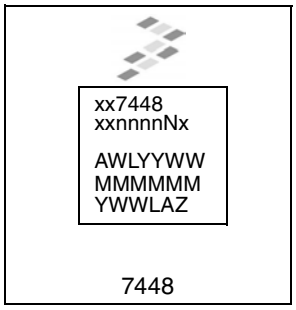
Product Code	Part Identifier	Specification Modifier	Package	Processor Frequency	Application Modifier	Revision Level
MC PPC[1]	7448	T = Extended Temperature Device	HX = HCTE BGA	1400	N: 1.15 V ± 50 mV – 40 to 105 °C	C: 2.1; PVR = 0x8004_0201 D: 2.2; PVR = 0x8004_0202
				1267 Revision C only	N: 1.1 V ± 50 mV – 40 to 105 °C	
				1267 Revision D only	N: 1.05 V ± 50 mV – 40 to 105 °C	
				1000	N: 1.0 V ± 50 mV – 40 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.

11.3 Part Marking

Parts are marked as the example shown in Figure 27.



BGA/LGA

Notes:

AWLYYWW is the test code, where YYWW is the date code (YY = year, WW = work week)
MMMMMM is the M00 (mask) number.
YWWLAZ is the assembly traceability code.

Figure 27. Part Marking for BGA and LGA Device