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Application Note

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# MPC7410 Package Options

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The purpose of this application note is to discuss the packaging options available for the MPC7410 product family. The original Ceramic Ball Grid Array (CBGA) package is scheduled for end-of-life (EOL) in mid-2008; this application note covers other packaging options for MPC7410 designs. The packages are described along with details of differences between the two primary package styles. Design and package migration implications are addressed in this document.

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## 1 References

The following documents contain related information on the MPC7410 packages. The latest *MPC7410 Hardware Specification* information supersedes any information in this Application Note.

- *MPC7410 RISC Microprocessor Hardware Specifications, Rev. 6* or later (Document Number: MPC7410EC). Referred to as the "*MPC7410 Hardware Specification*" in this document.
- *Chip Errata for the MPC7410* (Document Number: MPC7410CE).

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- *Manufacturing with the Land Grid Array Package* (Document Number: AN2920).
- *General Soldering Temperature Process Guidelines* (Document Number: AN3300).

# 2 MPC7410 Packages

The MPC7410 is available in several packages as shown in Table 1. The Ordering Information section of the *MPC7410 Hardware Specification* contains information on the part numbering nomenclature. There are normally two characters following the “7410” digits of the part number that indicate the package code of the device; those codes are shown in Table 1.

**Table 1. MPC7410 Package Options**

| Packaging Designator in Part Number | Package Description | Comments |
|---|---|---|
| RX | CBGA: Ceramic Ball Grid Array | This package is scheduled for EOL in mid-2008; not recommended for new designs.<br>C5 spheres contain lead (Pb). |
| HX | HCTE_CBGA: High Coefficient Thermal Expansion Ceramic Ball Grid Array | C5 spheres contain lead (Pb). |
| VU | HCTE_CBGA (Lead Free C5 Spheres): High Coefficient Thermal Expansion Ceramic Ball Grid Array with Lead Free C5 Spheres | C5 spheres are lead free (Pb-Free). |
| VS | HCTE_LGA: High Coefficient Thermal Expansion Land Grid Array | This package does not have C5 spheres attached. |

## 2.1 Package Options for Migrating from the CBGA Package

- The recommended replacement part for the RX (CBGA) is the HX (HCTE_CBGA) which has the same high lead (Pb) spheres as found in the CBGA package.
- The RoHS compliant recommended replacement packages are:
  — VU (HCTE_CBGA package with lead free C5 spheres) for customers requiring a lead free solder sphere package.
  — VS (HCTE_LGA package) has no solder spheres and may be attached to the printed circuit board (PCB) using either a Pb or Pb-free solder paste, depending on the system board requirements, with superior board level reliability when compared to the RX (CBGA) package. The VS package offers the most assembly-to-board process flexibility.

# 3 Differences Between CBGA and HCTE Packages

The difference between the end-of-life CBGA (RX) package and its HCTE (HX, VU and VS) replacements is the ceramic substrate technology. The new packages utilize a ceramic technology which has properties that provide improved board level reliability and enable the offering of RoHS compliant

parts. Parametric differences, basic package outline differences, and board level reliability are provided in this section.

## 3.1 Package Parameter Differences

The details of the differences between CBGA and HCTE packages are provided in Table 2.

**Table 2. MPC7410 CBGA vs. HCTE Differences**

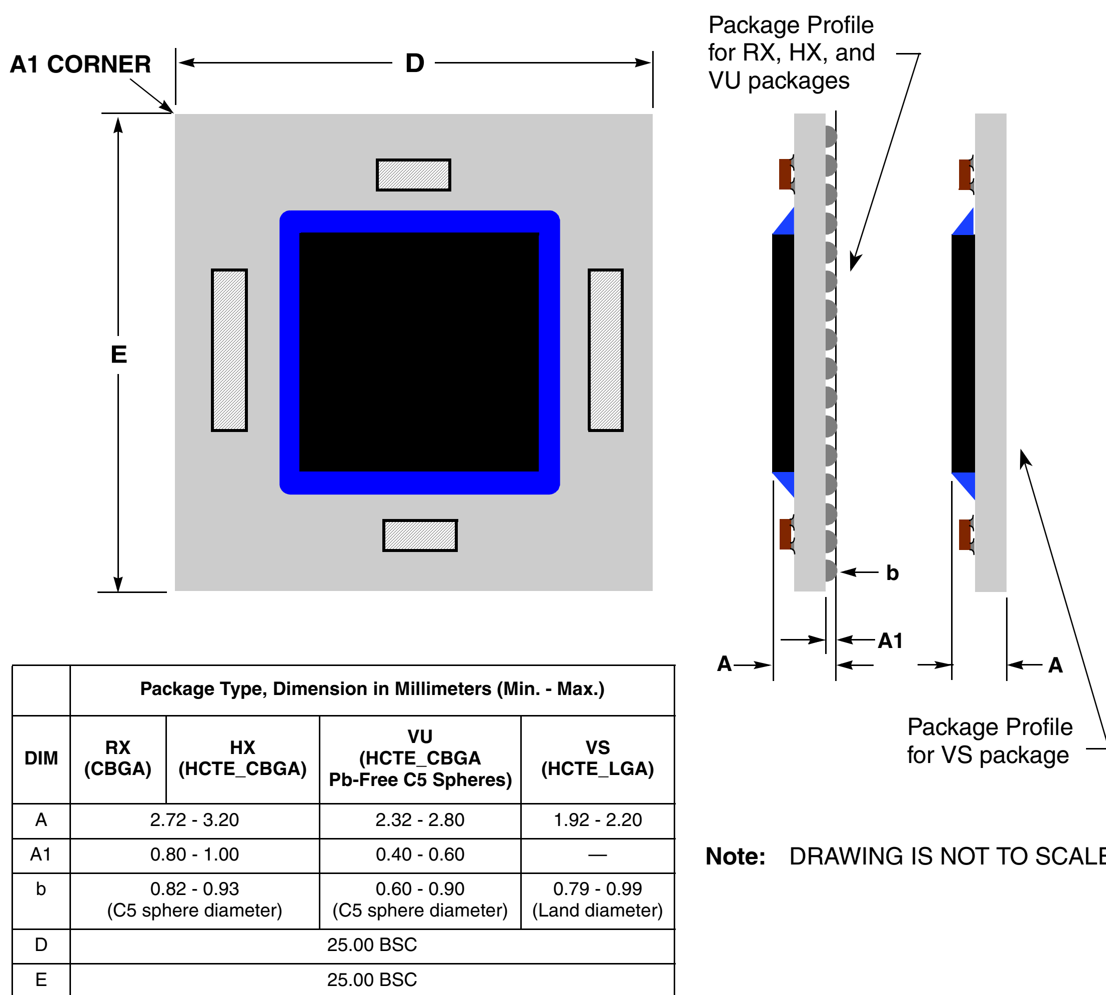
| Attribute | CBGA | HCTE | Comments |
|---|---|---|---|
| Package Designator and Dimensions | RX | HX, VU, VS | • All top view package dimensions remain the same.<br>• Key dimensions and mechanical outline of MPC7410 package options are shown in Figure 1.<br>• Refer to *MPC7410 Hardware Specification, Rev 6* or later for complete package dimension information. |
| Technology Type | HTCC<br>High Temperature Co-fired Ceramic (Alumina) | HiTCE LTCC<br>High Thermal Coefficient of Expansion - Low Temperature Co-fired Ceramic | |
| Coefficient of Thermal Expansion, CTE (@23 C) | 6.8 | 12.3 | • Seven times better board level reliability based upon Freescale reliability testing. Refer to Section 3.3, “Package Reliability Data”.<br>• HCTE Coefficient of Thermal Expansion more closely matched to typical PCB coefficient of thermal expansion of 14. |
| Thermal Conductivity (W/m-K) | 17 | 2 | Effective thermal conductivity for HCTE found to be similar to CBGA based on measured data.<br>(Similar thermal conductivity due to the copper filled vias in HCTE package between die and substrate; see Section 5.2, “Thermal Resistance”) for more information. |
| Thermal Resistance $R_{\Theta JA}$ | Refer to Table 3 and the *MPC7410 Hardware Specification, Rev 6* or later for thermal resistance information. | | |
| Conductor Material | Molybdenum (Mo) | Copper (Cu) base | |
| Conductor Resistance (mΩ/sq) | 8 | 3 | 60% lower conductor resistance for HCTE packages. |
| Dielectric Constant (@1 MHz) | 9.8 | 5.3 | Decrease time-of-flight delay in HCTE package by 25%. |
| Young's Modulus (GPa) | 280 | 75 | |
| Bending Strength (MPa) | 350 | 175 | |

**Table 2. MPC7410 CBGA vs. HCTE Differences**

| Attribute | CBGA | HCTE | Comments |
|---|---|---|---|
| Moisture Sensitivity Level | MSL1 260ºC | MSL1 260ºC | |
| Substrate Color | Purple | Light Green | |

## 3.2 Package Mechanical Outline Differences

Figure 1 illustrates the mechanical outlines and key dimensional differences for the MPC7410 packages. Refer to *MPC7410 Hardware Specification, Rev 6* or later for complete package dimension information.

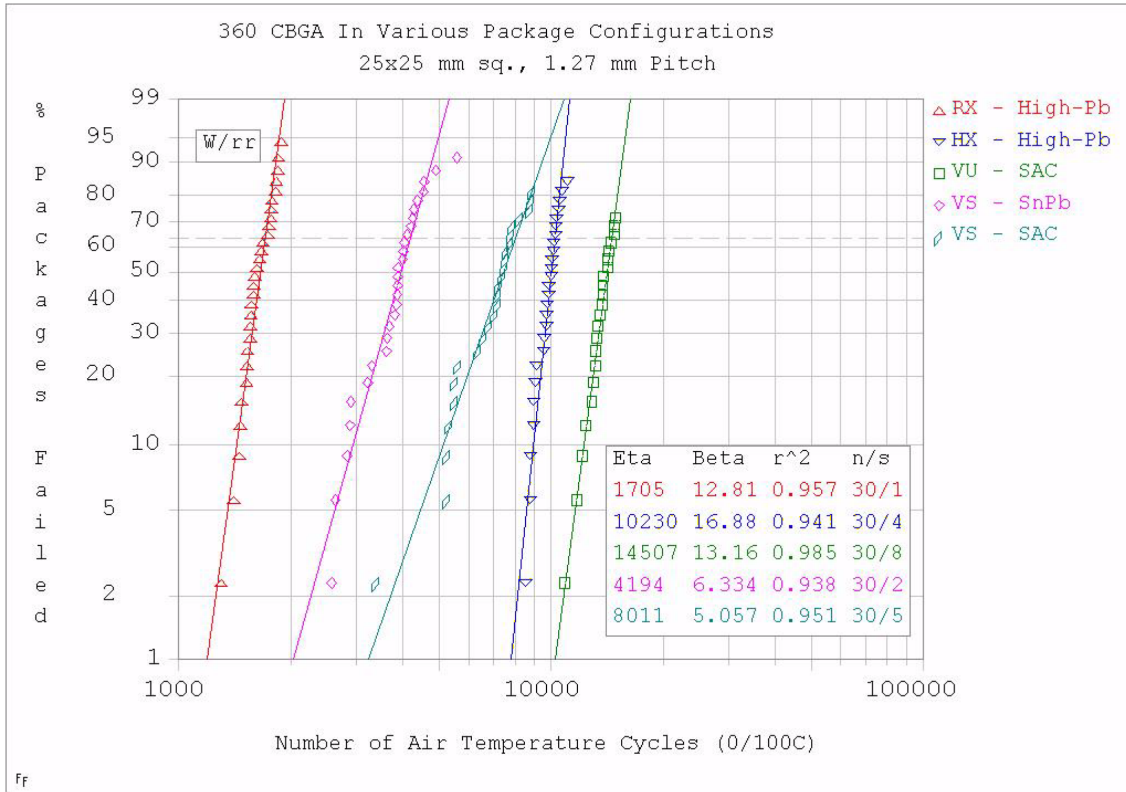



| DIM | Package Type, Dimension in Millimeters (Min. - Max.) | | | |
|---|---|---|---|---|
| | RX (CBGA) | HX (HCTE_CBGA) | VU (HCTE_CBGA Pb-Free C5 Spheres) | VS (HCTE_LGA) |
| A | 2.72 - 3.20 | | 2.32 - 2.80 | 1.92 - 2.20 |
| A1 | 0.80 - 1.00 | | 0.40 - 0.60 | — |
| b | 0.82 - 0.93 (C5 sphere diameter) | | 0.60 - 0.90 (C5 sphere diameter) | 0.79 - 0.99 (Land diameter) |
| D | 25.00 BSC | | | |
| E | 25.00 BSC | | | |

**Figure 1. Mechanical Outline and Key Dimensions for MPC7410 Packages**

## 3.3 Package Reliability Data

Figure 2 shows PCB temperature cycling reliability testing data (Weibull plot) for the different MPC7410 packages.




**Abbreviations:**
W/rr: Weibull in rank regression order.
SAC: Tin Silver Copper (Pb-Free) alloy.
SnPb: Tin Lead.
Eta: Number of cycles to 63.2% failure.
Beta: Slope of curve fit line.
r^2: Goodness of fit.
n/s: number of samples tested / samples still good at last read point.

**Figure 2. PCB Reliability Data for MPC7410 Packages**

# 4 Package Compatibility

- **Testing** - CBGA (RX), HCTE_CBGA (HX and VU), and HCTE_LGA (VS) packages are tested to and meet the same electrical timing specifications outlined in the *MPC7410 Hardware Specification*.
- **Pin Compatibility** - HCTE (HX, VU, and VS) devices are pin-pin compatible with the CBGA (RX) package. No board layout changes are required due to pin differences between the two packages. See Section 5.1, "MPC7410 Erratum 18 AVDD Filtering" for possible board layout changes related to Erratum 18 workarounds.
- **IBIS Models** - Are available for both CBGA (RX) and HCTE (HX, VU, and VS) packages at www.freescale.com/support.

# 5 System Design Considerations

AVDD supply pin filtering and thermal solutions need to be evaluated for possible system changes when migrating from CBGA (RX) to HCTE_CBGA (HX, VU, and VS) packages.

## 5.1 MPC7410 Erratum 18 AVDD Filtering

Erratum 18 in the *Chip Errata for the MPC7410* document explains an internal package noise issue which affects the CBGA (RX) package. The work around includes modifying the AVDD supply pin filter circuit to remove two filter capacitors and increasing the series resistance. Erratum 18 does not apply to the HCTE (HX, VU, and VS) packages; therefore, the work around is not necessary, and the AVDD filter for HCTE (HX, VU, and VS) packages described in the *MPC7410 Hardware Specification* is necessary.

## 5.2 Thermal Resistance

The junction-to-ambient thermal resistance for the HCTE (HX, VU, and VS) packages is greater than the CBGA (RX) junction-to-ambient thermal resistance by approximately 11% to 16% depending upon the airflow conditions. The junction-to-board thermal resistance for the HCTE_CBGA packages (HX, VU, and VS) is greater than the CBGA (RX) junction-to-board thermal resistance by approximately 23%. Complete details are provided in the *MPC7410 Hardware Specification* and are shown in Table 3.

Because of this increased resistance to the conductivity of heat in the HCTE (HX, VU, and VS) packages, it is recommended that existing thermal solutions for CBGA (RX) packages be re-evaluated for sufficient heat dissipation in HCTE (HX, VU, and VS) applications.

**Table 3. Package Thermal Characteristics**

| Characteristic | Symbol | Value | | Unit | Notes |
|---|---|---|---|---|---|
| | | CBGA (RX) | HCTE (HX, VU, and VS) | | |
| Junction-to-ambient thermal resistance, natural convection, four-layer (2s2p) board | $R_{\theta JMA}$ | 18 | 20 | °C/W | 1, 2 |
| Junction-to-ambient thermal resistance, 1m/sec airflow, four-layer (2s2p) board | $R_{\theta JMA}$ | 14 | 16 | °C/W | 1, 2 |

**Table 3. Package Thermal Characteristics (continued)**

| Characteristic | Symbol | Value | | Unit | Notes |
|---|---|---|---|---|---|
| | | CBGA (RX) | HCTE (HX, VU, and VS) | | |
| Junction-to-ambient thermal resistance, 2m/sec airflow, four-layer (2s2p) board | $R_{\theta JMA}$ | 13 | 15 | °C/W | 1, 2 |
| Junction-to-board thermal resistance | $R_{\theta JB}$ | 9 | 11 | °C/W | 3 |
| Junction-to-case thermal resistance | $R_{\theta JC}$ | < 0.1 | < 0.1 | °C/W | 4 |

**Notes:**
1. Junction temperature is a function of die size, on-chip power dissipation, package thermal resistance, mounting site (board) temperature, ambient temperature, air flow, power dissipation of other components on the board, and board thermal resistance.
2. Per JEDEC JESD51-6 with the board horizontal.
3. 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.
4. Thermal resistance between the active portion of the die and the calculated case temperature at the top of the die. The actual value of R JC is less than 0.1 °C/W.

## 5.3 Thermal Solution (Heat Sink) Mounting Considerations

- The CBGA (RX) and HCTE_CBGA (HX) packages drawings are the same in the *MPC7410 Hardware Specification*. There should be no heat sink mounting differences issues between these two packages.
- The HCTE_CBGA package with lead free C5 spheres (VU) package dimensions shown in the *MPC7410 Hardware Specification* and Figure 1:
  - ‘A’ (overall side profile height from bottom plane of solder spheres to the back (top) of the die)
  - ‘A1’ (height from bottom plane of solder spheres to the bottom of the package substrate)
  - ‘b’ (solder sphere diameter)

  are less than the same dimensions of the CBGA (RX) package meaning the final mounted HCTE_CBGA package with lead free C5 spheres (VU) package will sit closer to the PCB after the soldering assembly process. Care must be taken to ensure the heat sink and thermal interface material is mounted to maintain firm contact with the back of the die of the VU package. Adjustments for heat sink spring clips-to-holes in the PCB and screw mounted heat sinks may be necessary. Heat sinks that spring clip to the edge of the substrate are no longer recommended due to potential substrate package deformation and may not have enough PCB to package clearance to be used in VU package designs.
- While the HCTE_CBGA package with lead free C5 spheres (VU) package dimensions: ‘A1’ and ‘b’ do not apply to the HCTE_LGA (VS) package (refer to *MPC7410 Hardware Specification*), similar post solder processing dimension concerns with respect to heat sink mounting outlined for the VU package above are applicable for the VS package.

# 6 Revision History

Table 4 provides a revision history for this application note.

**Table 4. Document Revision History**

| Rev. Number | Date | Substantive Change(s) |
|---|---|---|
| 0 | 09/06/2007 | Initial release. |

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