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## WHITE PAPER

### Thermal Characteristic Comparison of the PQ2 and PQ4 Packages (208 Lead SQFP) as Used in the IntelDX4™ Processor Family

#### References

Intel Product Change Notification #253

#### Description of Change

The purpose of this white paper is to communicate the thermal differences between the PowerQuad\* 2 (PQ2) and PowerQuad 4 (PQ4) packages as used in the IntelDX4™ processor product family.

For the mobile computing market segment, Intel initially produced a surface-mount IntelDX4 processor in a package referred to as the PowerQuad 2 (PQ2) package. This package is a 208 lead Shrink Quad Flat Pack (SQFP) package in which the die is mounted to a metal heatsink (heat slug) integrated into a molded plastic case. This package allows the IntelDX4 processor to run reliably in a low-profile plastic package.

On March 29, 1996, Intel announced the end-of-life of the PQ2 package version of the IntelDX4 processor (Intel PCN #253), with a two-year end-of-life support period.

In August of 1997, for the embedded market segment, Intel announced the introduction of a new version of the 208 lead SQFP package for the IntelDX4. This new package, referred to as the PowerQuad 4 (or PQ4) package, has slightly degraded thermal characteristics compared to the PQ2 package.

#### Products Affected

This white paper pertains only to the IntelDX4 processor. Specific order codes are listed below:

##### *IntelDX4 Processor Products Utilizing the PowerQuad 2 Package*

*(Discontinued—Final order date: 9/29/97, Final ship date: 3/29/98)*

Order Code	Spec	Description
FC80486DX4WB75	SK100	208L SQFP, Write-back cache, 75 MHz
FC80486DX4WB100	SK099	208L SQFP, Write-back cache, 100 MHz

##### *New Replacement IntelDX4 Processor Products Utilizing the PowerQuad 4 Package*

*(Samples available now. Full production qual achieved. Production shipments start no later than 3/15/98.)*

Order Code	Spec	Description
FC80486DX4WB100	Q860	208L SQFP, Write-back cache, 100 MHz Sample Order code
FC80486DX4WB100	SL2M9	208L SQFP, Write-back cache, 100 MHz –Production Spec

Note: The above products support 75MHz operation as well.

#### Impact of Change and Recommended Action

Intel believes that most applications will see no significant impact in either electrical or thermal performance when changing over from the PQ2 to the PQ4 package; however, Intel advises that each customer consider these differences in their individual applications. This white paper details those differences. It is up to the customer application design team to ascertain the impact of thermal performance when changing over from the PQ2 to the PQ4 package on the IntelDX4 processor. (NOTE: Although there are different thermal characteristics between the PQ2 and PQ4 packages, the lead footprint, pinout, and all outer dimensions of the package are identical.)

\*Third-party brands and names are the property of their respective owners.

## PowerQuad 2 Package Features and Characteristics

The PowerQuad 2 is a patented, advanced packaging technology with thermal and electrical performance attributes. Gains in power dissipation and speed are achieved through the use of an integrated, embedded copper heat slug. The IntelDX4 processor die is attached directly to this heat slug, which extracts heat under operating conditions. To enhance the thermal conduction from the IntelDX4 processor die to the mounting surface, the internal package leads of the PQ2 package are mechanically connected, yet electrically isolated, by a proprietary process to the heat slug. The large heat slug also provides a "floating" ground plane to the signal leads, reducing self-inductance by 50% (over conventional plastic QFPs).

The result is a high-power, high-speed processor in a smaller, more cost-effective package with properties to enable the processor to meet or exceed thermal requirements.

Features of the PowerQuad 2 (208 lead, 28x28mm outer package dimension):

- Highly conductive, solid copper heat slug for heat dissipation
- Lead frame mechanically attached to the heat slug

Thermal and electrical performance of the PowerQuad 2:

- 50% reduction in package self-inductance compared to QFP
- 50% improvement in Theta j-a (junction-to-ambient spec) over standard MQFP

Thermal Resistance (°C/W):

- Theta j-c (junction-to-case temperature spec).....0.3
- Theta j-a (junction-to-ambient spec with Zero Linear Foot Per Minute airflow) ..... 16.0

Electrical (typical):

- Self inductance (nH)..... 7.20
- Mutual inductance (nH) ..... 3.88
- Mutual capacitance (pF)..... 0.49

### PowerQuad 4 Package Features and Characteristics

Similar to the PowerQuad 2 (PQ2) package, power dissipation in the PowerQuad 4 (PQ4) package is achieved by an integrated embedded copper heat slug, with the die mounted to the heat slug. In addition, the heat slug in the PQ4 package has a built-in mechanical package-encapsulant “lock” feature to improve package integrity and eliminate moisture penetration. The most significant difference between the PQ2 and PQ4 package is that inside the PQ4 package the leadframe is not mechanically attached to the heat slug. The result is an IntelDX4 processor with slightly different thermal conditions. The footprint, pinout and dimensions of the PQ2 vs. the PQ4 are identical. Please review the data presented below on thermal resistance to determine if this changeover requires a modification to your application.

Features of the PowerQuad 4 (208 lead, 28x28mm outer package dimension):

- Highly conductive, solid copper heat slug for heat dissipation
- New encapsulant “lock” to ensure package integrity and eliminate moisture penetration
- Lead frame mechanically separated from the heat slug

Thermal and electrical performance of the PowerQuad 4:

- 50% reduction in package self-inductance compared to QFP
- >40% improvement in Theta j-a (junction-to-ambient spec) over standard MQFP

Thermal Resistance (°C/W):

- Theta j-c (junction-to-case temperature spec)..... 1.5
- Theta j-a (junction-to-ambient spec with Zero Linear Foot Per Minute airflow) ..... 20.0

Electrical (typical):

- Self inductance (nH)..... 7.20
- Mutual inductance (nH) ..... 3.88
- Mutual capacitance (pF)..... 0.49