AP-973

Application Note

Pentium® III Xeon™ Processor with 1MB and 2MB L2 Cache

Thermal Solutions Guidelines

Order number 245489-001
May, 2000

Copies of documents which have an ordering number and are referenced in this document, or other Intel literature, may be obtained from:

Intel Corporation
P.O. Box 7641
Mt. Prospect, IL 60056-7641

or call 1-800-879-4683
or visit Intel’s website at http://www.intel.com

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1. INTRODUCTION

This Application Note is intended to provide information about Intel's reference heat sink solution for the Pentium® III Xeon™ processor with 1MB and 2MB L2 cache. In addition, alternative processor cooling approaches are discussed.

2. TERMINOLOGY

The following terms are used in this document and are defined here for clarification:

- **Pentium® III Xeon™ processor with 256KB L2 cache -** refers to a Pentium III Xeon processor which utilizes On Cartridge Voltage Regulator technology, or ***"OCVR"***, and which has 256KB of Level 2 cache. The OCVR regulates V_{CC_CORE} (the appropriate cartridge input voltage) to the required processor core voltage (V_{CC_CPU}). The OCVR was developed to provide the necessary regulation to guarantee the highest possible frequency of operation for the Pentium III Xeon processor at 600 MHz and above.
- **Pentium® III Xeon™ processor with 1MB and 2MB L2 cache -** refers to a Pentium III Xeon processor which utilizes On Cartridge Voltage Regulator technology, or ***"OCVR"***, and which has either 1MB or 2MB of Level 2 cache. The OCVR regulates V_{CC_CORE} (the appropriate cartridge input voltage) to the required processor core voltage (V_{CC_CPU}). The OCVR was developed to provide the necessary regulation to guarantee the highest possible frequency of operation for the Pentium III Xeon processor at frequencies of 600 MHz and above.
- **Pentium® III Xeon™ processor at 500 MHz and 550 MHz -** refers to a Pentium III Xeon processor without an OCVR, and requires separate Vcc CORE and L2 voltage sources.
- **Pentium® III Xeon™ processor -** refers to any Pentium III Xeon processor with 256KB L2 cache, Pentium III Xeon processor with 1MB and 2MB L2 cache, or Pentium III Xeon processor at 500 MHz and 550 MHz.
- **L2 cache** —The L2 cache is integrated directly on the processor core for the Pentium III Xeon processor with 256KB L2 cache and the Pentium III Xeon processor with 1MB and 2MB L2 cache, or is located on the substrate for the Pentium III Xeon processor at 500 MHz and 550 MHz.
- **2.8V Pentium® III Xeon™ processor** — refers to a Pentium III Xeon processor with 256KB L2 cache or a Pentium III Xeon processor with 1MB and 2MB L2 cache which can be powered with +2.8 volts applied to its VCC_CORE pins.
- **5/12V Pentium® III Xeon™ processor** — refers to a Pentium III Xeon processor with 256KB L2 cache or a Pentium III Xeon processor with 1MB and 2MB L2 cache which can be powered with either +5.0 or +12.0 volts applied to its VCC_CORE pins.
- **Processor substrate** — The structure on which components are mounted inside the S.E.C. cartridge (with or without components attached).
- **Processor core** — The processor's execution engine.
- **S.E.C. cartridge** — The processor packaging technology used for the Pentium® III Xeon™ processor family. S.E.C. is short for "Single Edge Contact" cartridge.
- **Thermal plate** — The surface used to connect a heat sink or other thermal solution to the processor.

3. REFERENCES

The reader of this Application Note should also be familiar with material and concepts presented in the datasheets, applications notes, and other documents for the Pentium® III Xeon™ processor family. These are found at:

http://developer.intel.com/design/pentiumiii/xeon/

4. REFERENCE THERMAL SOLUTION

The reference passive heat sink solution that was designed for the Pentium® III Xeon™ processors at 550 MHz can provide adequate cooling for the Pentium III Xeon processor at 700 MHz with 1MB and 2MB L2 cache (based on certain airflow and ambient temperature assumptions, described in greater detail in this document). See Chapter 5 for heat sink ordering information.

4.1 Thermal Assumptions

Table 38 in the latest Pentium® III Xeon™ processor at 500 MHz and 550 MHz datasheet (Order Number 245094) shows the maximum L2 cache power, which does not occur simultaneously with the maximum processor core power. The worst case condition for the thermal design occurs when the processor core is at maximum power and the cache is idle, since the power density is higher in this case. 40.5 Watts is the actual worse case power dissipation for the Pentium III Xeon processor at 550 MHz in this condition.

Since the OCVR component does not come into contact with the processor thermal plate, and its power is removed by conduction through the cartridge substrate (as well as by both natural convection and radiation), the thermal contribution of the OCVR can be derated to 50% of its worst case power dissipation. This analysis is based on previous data from the Pentium II processor in the S.E.C.C. package, where it was concluded that if the thermal grease was removed between the thermal plate and the L2 cache components, 50% of the L2 cache power still dissipates through the thermal plate. Since the OCVR package configuration is similar, 50% of the OCVR power is assumed to be dissipated through the thermal plate.

4.2 Thermal Analysis

The performance of any thermal solution is defined as the thermal resistance between the thermal plate and the ambient air around the processor (θ plate to ambient). The lower the thermal resistance between the thermal plate and the ambient air, the more efficient the thermal solution is. The required θ plate to ambient is dependent upon the maximum allowed thermal plate temperature (TPLATE), the local ambient temperature (TLA – the air around the processor) and the thermal plate power (PPLATE).

$$\theta_{\text{plate to ambient}} = (T_{PLATE} - T_{LA}) / P_{PLATE}$$

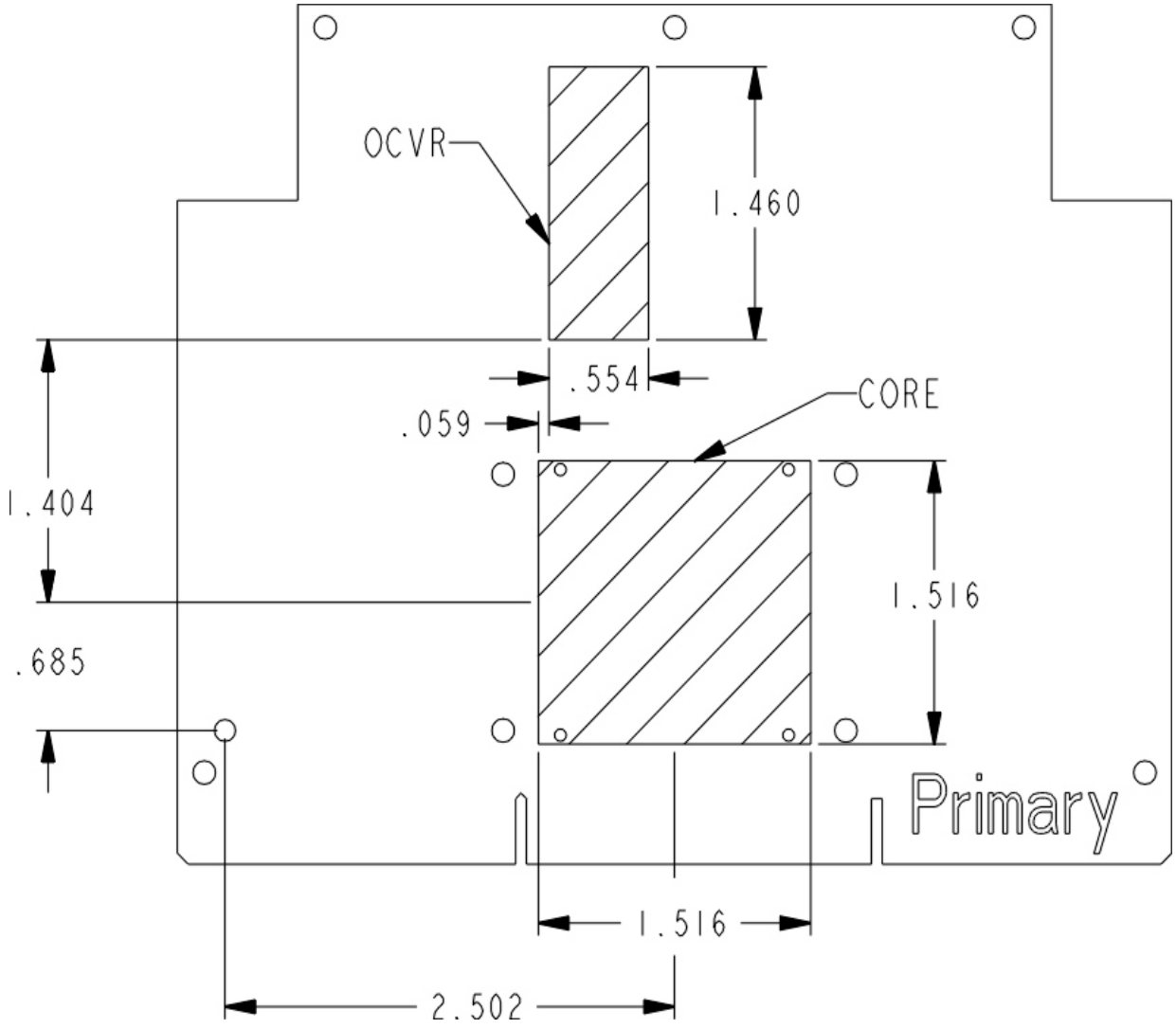

Figure 1. Thermal density areas of Pentium® III Xeon™ processor with 1MB and 2MB L2 cache core and OCVR components

4.3 Thermal Conclusion

The reference passive heat sink will keep the Pentium® III Xeon™ processor with 1MB and 2MB L2 cache thermal plate temperature at or below its specified value, if the local ambient temperature (T_{LA}) is maintained at 40°C or less, with an airflow of at least 300 LFM.

4.4 Pentium® III Xeon™ Processor with 1MB and 2MB L2 Cache Thermal Update

The Pentium® III Xeon™ processor with 1MB and 2MB L2 cache OLGA-2 Integrated Heat Spreader size is 1.516" X 1.516", as shown in Figure 1. The *effective* heat source size of the Pentium® III Xeon™ processor with 1MB and 2MB L2 cache with OLGA-2 Integrated Heat Spreader is two times that of the Pentium III Xeon processor with 256KB L2 cache core size (which uses the OLGA-1 package) of 0.448" X 0.362". The *2X* factor has been determined by analytical and empirical data.

The performance of the Pentium III Xeon processor at 550 MHz reference heat sink will improve significantly due to the heat source size increase with the package change from OLGA-1 on the Pentium III Xeon processors with 256KB L2 cache to the OLGA-2 package on the Pentium III Xeon processors with 1MB and 2MB L2 cache. Consequently, the heat sink thermal resistance (θ_{PA}) will decrease. Without accounting for the reduction in θ_{PA}, the present reference thermal heat sink solution satisfies the T_{PLATE} requirement of 65°C for Pentium III Xeon processors with 1MB and 2MB L2 cache.

5. HEAT SINK SAMPLE INFORMATION

A passive heat sink is available from several vendors, including Thermalloy (part number 22730U-CP35). See Figure 2 below. For more mechanical information refer to Chapter 9 of the latest Pentium® III Xeon™ processor with 1MB and 2MB L2 cache datasheet (Order Number 248711). For heat sink assembly information contact your Intel representative or contact Thermalloy at:

Thermalloy, Inc.
2021 W. Valley View Lane
Dallas, TX 75234
Tel (972) 488-4257
Fax (972) 488-4461

http://www.thermalloy.com/

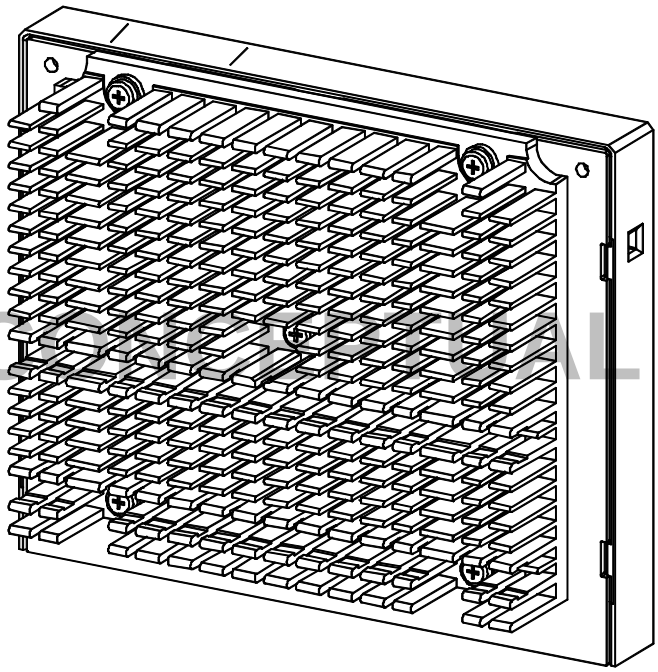

Figure 2. Reference passive heat sink

6. COMMON QUESTIONS

Q: If my present chassis and heat sink was designed to accommodate the Pentium® III Xeon™ processor at 550 MHz, will I have to perform additional thermal analysis?

A: Yes. Even though data indicates the present Pentium III Xeon processor at 550 MHz heat sink will support all Pentium III Xeon processors with 1MB and 2MB L2 cache, if the local temperature can be held to 40°C, Intel still recommends performing a thermal analysis of your system.

Q: Does Intel plan on enabling any other heat sink solution (other than the Thermalloy 22730U-CP35 or equivalents)?

A: There are additional heat sink vendors at the Intel developer website that may have solutions that could meet your needs. Refer to:

http://developer.intel.com/design/pentiumii/xeon/components/