System Considerations for Dual AMD Athlon™ MP Processors in Tower and 1U Form Factors

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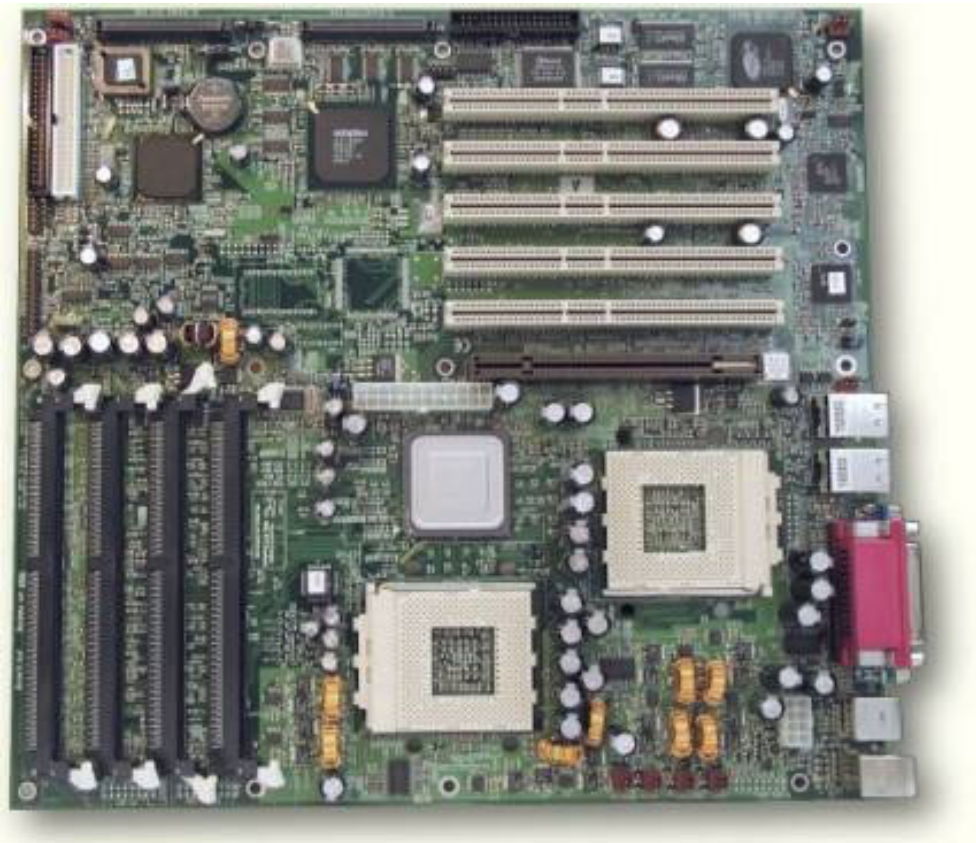
Outline

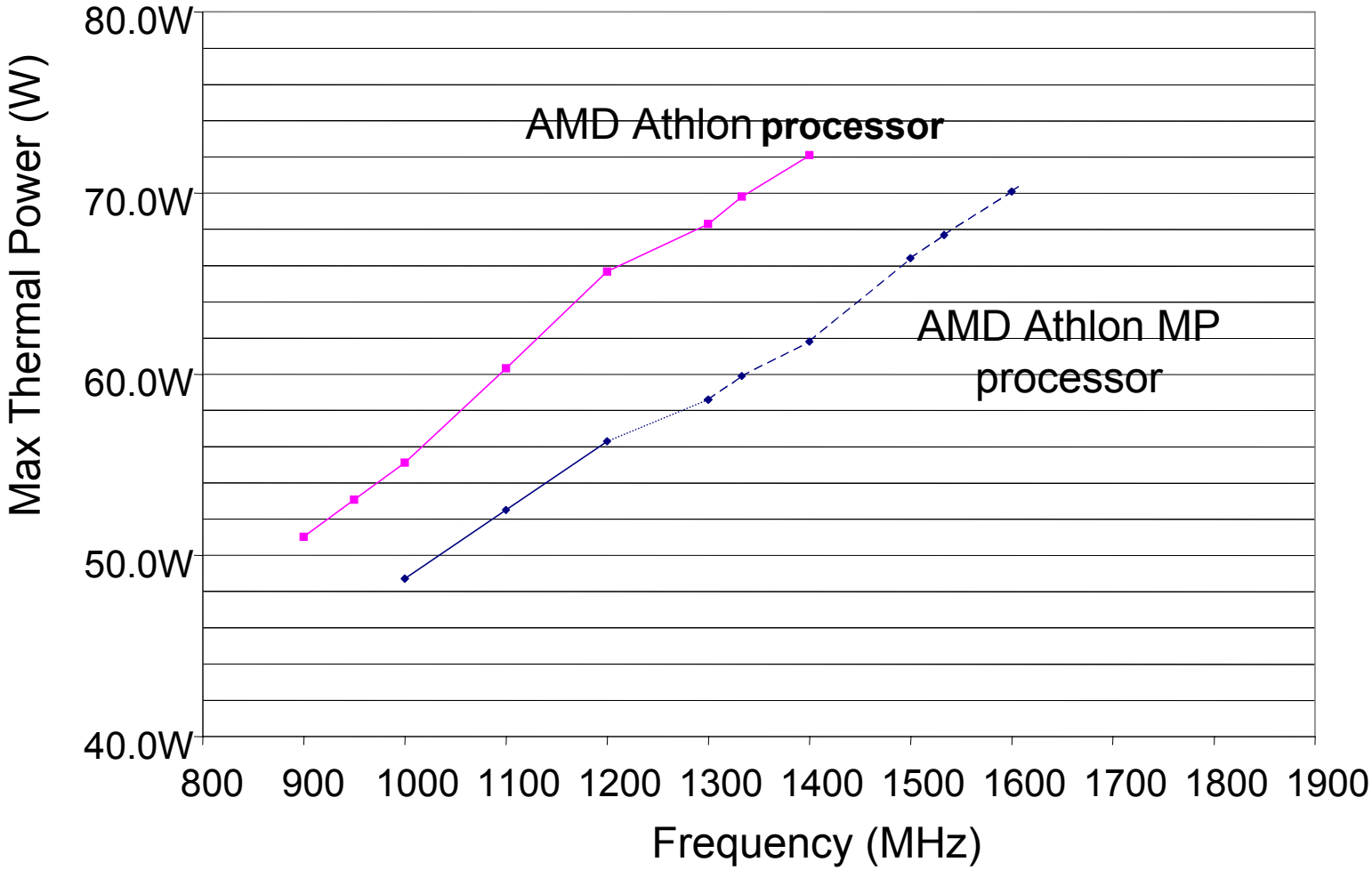
- **Introduction**
- **AMD Athlon™ MP processor power roadmap**
- **Thermal test methodology**
- **Tower chassis form factor**
  - Chassis vendors and models
  - Power supplies
  - Heat sinks
  - Thermal test results
- **1U drawer form factor**
  - Recommended 1U drawer floor plan
  - Heat sinks
  - Thermal test results
- **Summary**

Introduction



- **AMD-760™MP chipset**
- **Support for two AMD Athlon™ MP processors**
- **Support for 200 MHz and 266 MHz front-side bus**
- **Support for up to 3 GB PC2100 registered DDR RAM**
- **Extended ATX Form Factor**
- **AGP Pro slot, five 64-Bit PCI slots, VGA slot**
- **One serial port, one parallel port, two USB (four through optional cable), PS2 keyboard and mouse connections**
- **Up to four Enhanced IDE devices**
- **Dual 3COM LAN controllers**
- **Integrated ATI Rage XL graphics accelerator**

AMD Athlon™ Processor Power Roadmap



Thermal Test Methodology

Thermal Requirements

- Processor die temperature should not exceed the maximum temperature specification (90°C or 95°C).
- 35°C external ambient
- Maximum thermal power at specification
- Northbridge, power FETs, and other components in system should not exceed their temperature specifications.

Overview

- Single processor
  - Software—Maxtherm Option F run under DOS
  - Use single-processor thermal test Excel spreadsheet for analysis
- Dual processor
  - Software—BurnK6
    - Run two instances under Windows® OS
    - Run two instances for Linux OS (under two logins)
  - Available at http://users.ev1.net/~redelm/
  - Use dual-processor thermal test Excel spreadsheet for analysis
- Power dissipation: calibrate one or two processors
  - As function of software, voltage, and temperature
  - Run one test with one set of processors
  - Analyze data versus power specification
- Thermocouple locations of interest

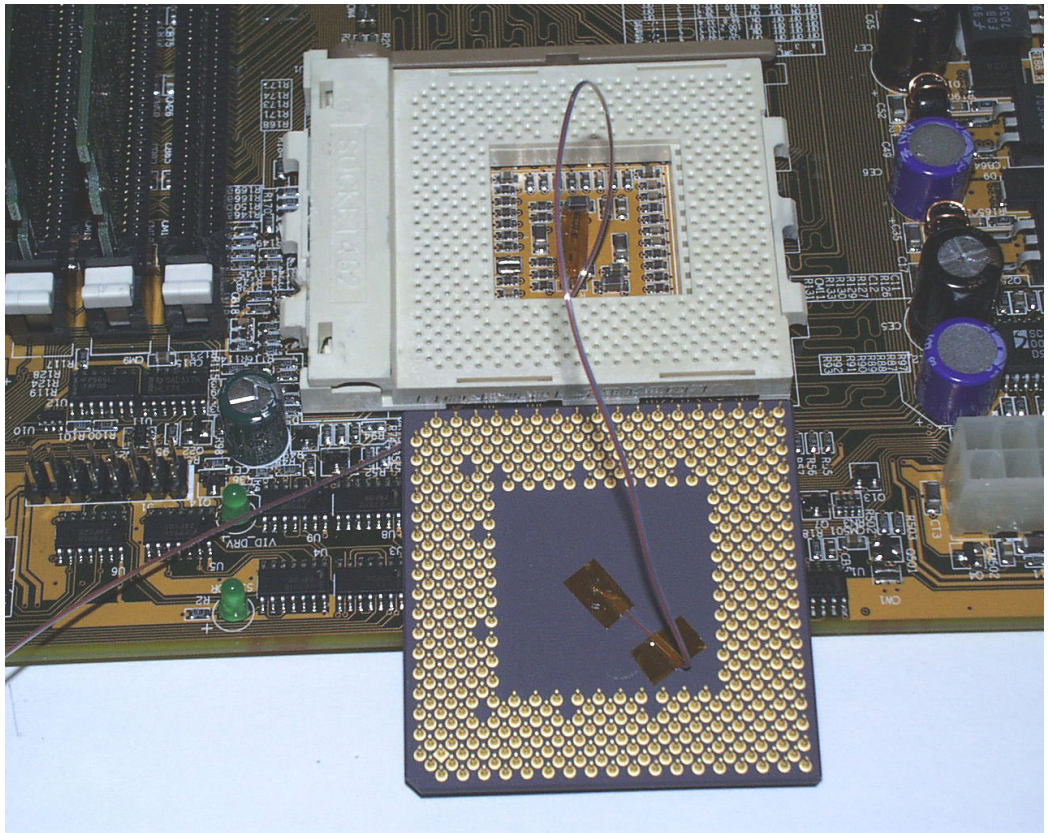
Test Methodology

- Measurements taken at room temperature
  - Temperature-controlled fans in power supply are run with voltage at 35°C setting.
- Software used to power processor
  - Single processor tests use Maxtherm Option
  - Dual processor tests utilize either BurnK6 freeware or other software
- Thermocouples placed at following locations:
  - Back of ceramic of PGA package for each processor
  - Heat sink base for each processor
  - Ambient for each processor
  - FET case for each processor
  - Under motherboard at Northbridge
  - Power supply exhaust
  - System fan exhaust (if applicable)
  - External ambient
- Vcc core feedback monitored for each processor

Test Methodology (…cont.)

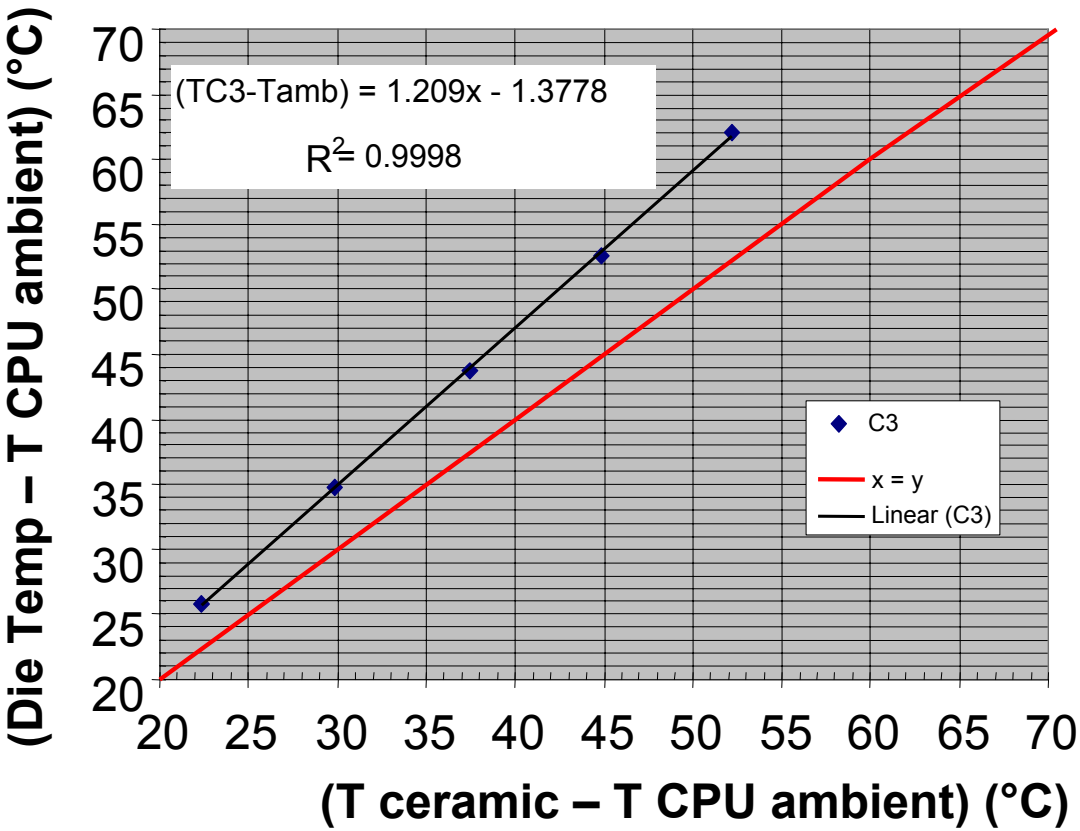
- Power supply fan voltage is monitored or set at voltage at which it would run at maximum external ambient temperature.
- Determination of processor power consumption
  - Processor placed in modified motherboard used for measuring power
  - Current readout measured with Vcc feedback voltage set to match voltage measured during thermal test
  - Maxtherm Option F and BurnK6 or other software run for test
  - Power measured at close to same temperature of test
  - Power used in spreadsheet = Vcc Voltage x Current (as measured through CoreFB– and CoreFB+ pins (AG11 and AG13) on the processors)

Indirect Temperature Measurement Method



- Simple, repeatable method
- Attach thermocouple to back of ceramic substrate of processor
- Centered on die area
- Use provided correlation for determining die temperature

Correlation for Indirect Die Temperature Method for Products without Diodes

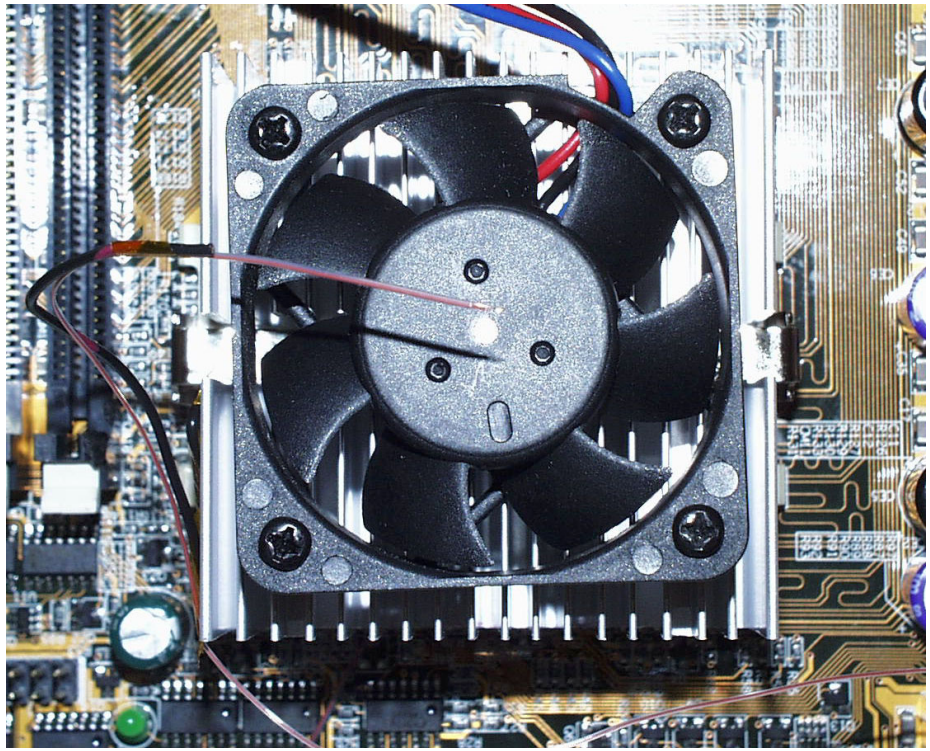


Typical residual: ± 2°C for centered clip

- Correlation relates die temperature to backside ceramic temperature
- Referenced to local CPU ambient
- Measurements performed on a thermal test vehicle
- Power varied to create correlation
- Validated against multiple, more involved methods of making temperature measurement

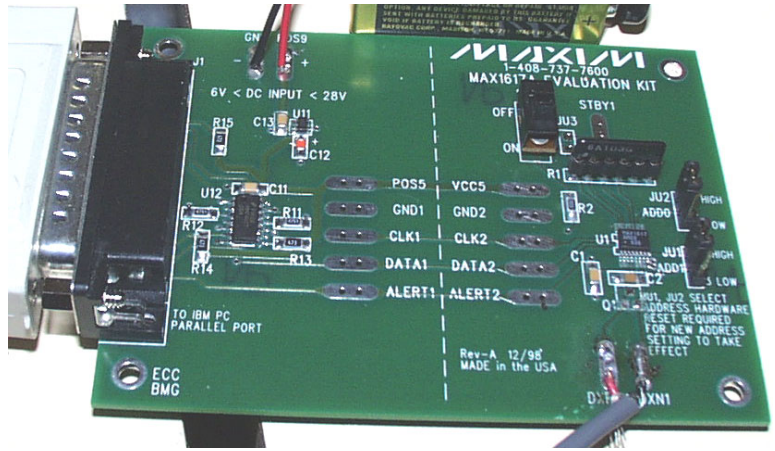
CPU Ambient Thermocouple

- Thermocouple should be centered above the fan hub
- One inch above the center of the fan hub
- Tape it to stiff wire that can be formed to place it in this location

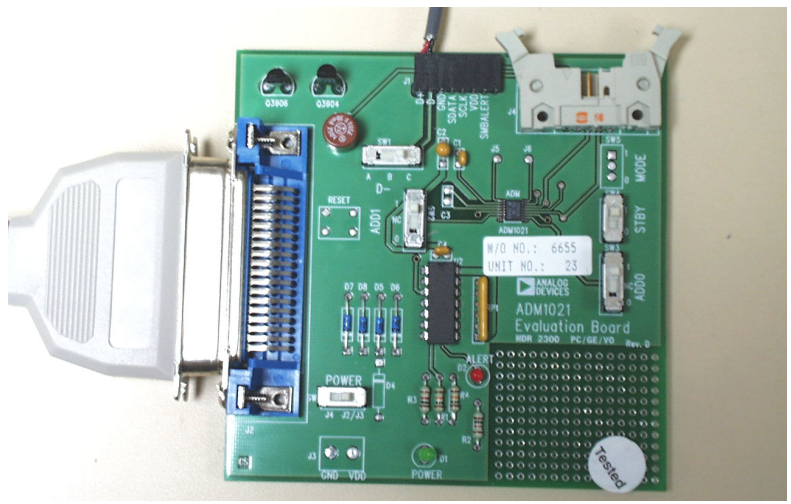


Evaluation Temperature Sensor Kits

- Maxim 1617A Evaluation Kit

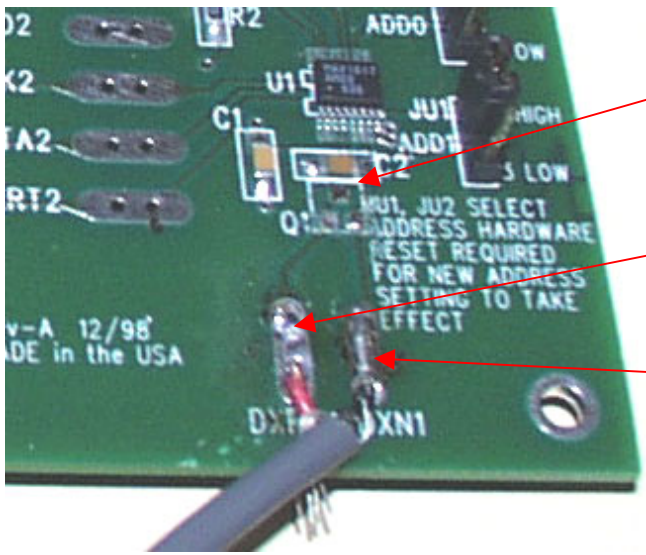


- Analog 1021A Evaluation Kit



Connect to the On-Die Temperature Diode

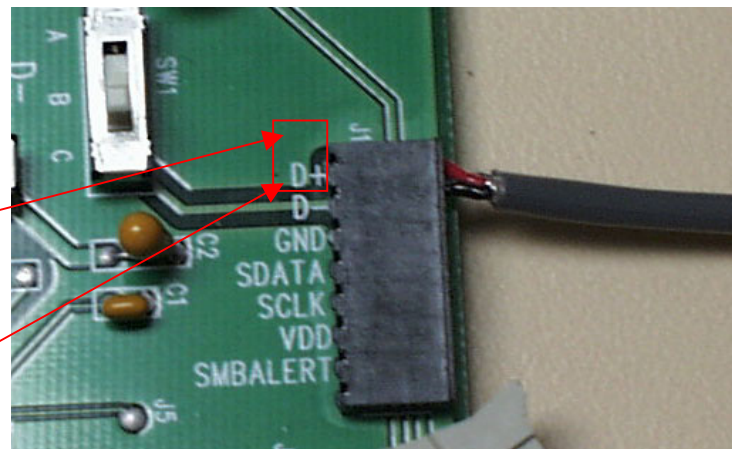
- Attach temperature sense wires to the evaluation kit
  - S7 wire connects to the positive terminal (DXP1 or D+)
  - U7 wire connects to the negative terminal (DXN1 or D–)



Remove this remote diode

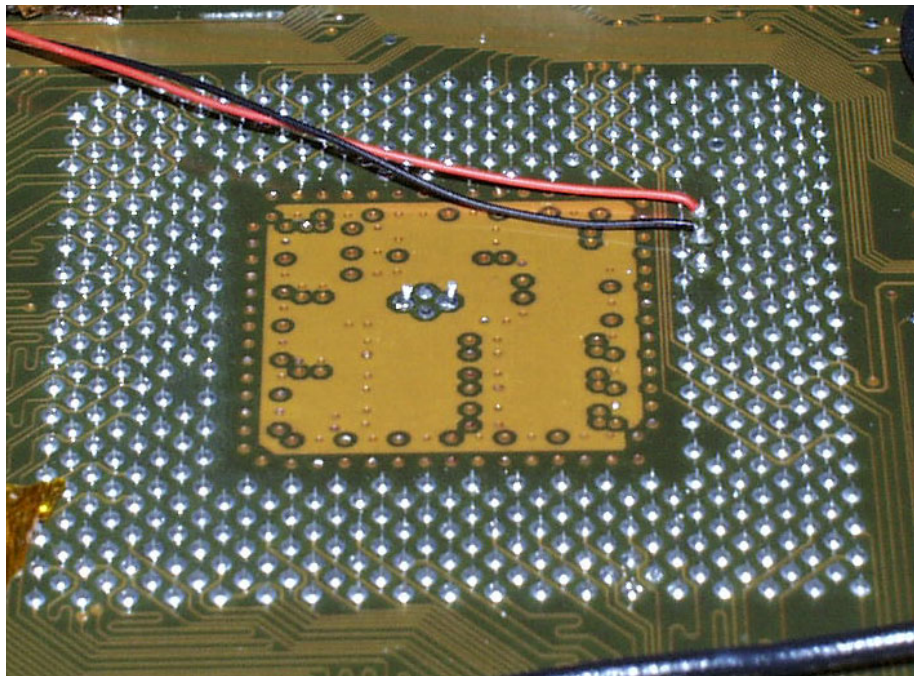
Positive terminal

Negative terminal



Connect to Vcc Core Feedback Pins

- Connect 30-gage wire to Vcc core feedback positive and negative pins AG11 and AG13 (see processor pinout on next page)
- Allows monitoring of exact voltage across processor



Processor System Data Analysis

- Room temperature data extrapolated to 35°C
- Die temperature calculated using following correlation for ceramic packages:
  - (Tdie – Tamb) = 1.209 × (Tceramic – Tamb) – 1.3778
- θ js and θ sa calculated
- Maximum Allowable Power (MAP) at 35°C calculated:
  - MAP = (90 °C or 95°C–Tamb)/ θ ja
- Projected die temperature calculated:
  - Tdie = Power(from MTP table) × θ ja+Tamb

Data Analysis

- MAP compared to Max Thermal Power (MTP)
- Example:
  - MAP = 54W
  - From table, maximum frequency support = 1000MHz
- Max thermal power
  - represents +3sigma power dissipation of product
  - at a given frequency and nominal voltage

MTP Table:

	AMD Athlon™ Processor 1.75 V SpecFP*
frequency	Max Thermal power:
D/C power	9
650	36.1
700	38.3
750	40.5
800	42.6
850	44.8
900	49.1
950	51.4
1000	51.0
1100	55.3
1200	59.6
1300	63.9
1400	68.2

54 W max thermal power surpasses 1.0 GHz, but is not enough for 1.1 GHz.

Tower Form Factor Guidelines

25325B August 2002

Thermal Design for Dual AMD Athlon™ MP Systems in Tower Form Factor

- Layout motherboard using keepout region definition for single processor systems
- Use a single qualified heat sink for each processor
- Use system fans to reduce temperature rise from external to the chassis to the processor locations
- Manage acoustics of system through fan speed control
- Chassis are standard product offerings from various chassis vendors

Chassis

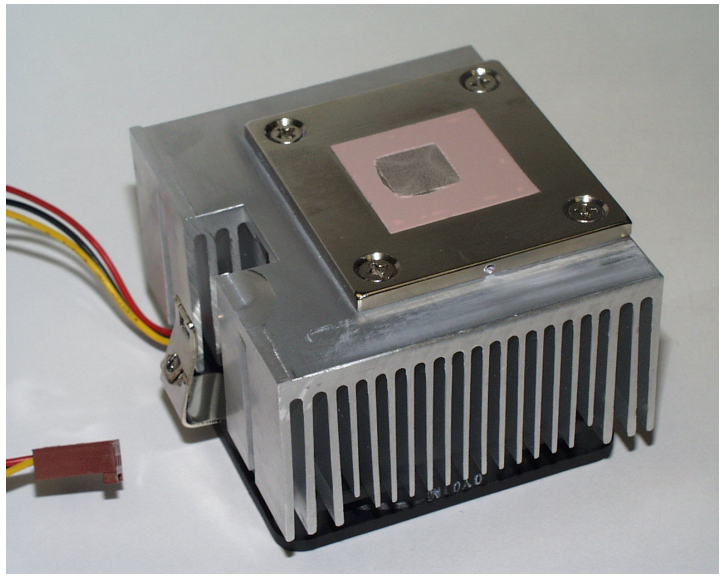
- ChenMing 601AE-F-D *
- Palo Alto 810*
- Chenbro 2012 / 2025*
- Evercase EC S5000
- Inwin QS5000

*Will present test results

Heat Sinks for Dual Processor Implementations in Tower Form Factor

- Use standard single processor desktop heat sinks.
- Heat sink frequency rating is based on the following criteria:
  - Maximum external system ambient = 35°C
  - External-to-internal temperature rise ≤ 14°C
  - Power dissipation is at the maximum specification.
  - Die temperature ≤ maximum specification
- External-to-internal temperature rise must meet the above criteria.
- IMPORTANT: System integrator must confirm that processor temperature specification is met.

Heat Sink Incorporating Copper



- Foxconn PK0453AEDAU52
  - 63 x 70 x 60 mm
  - Basic aluminum extrusion
  - 50 x 50 x 3mm Ni-plated Cu slug
    - Attached with four screws
    - Shinetsu G751 grease

Dual AMD Athlon™ Processor Tower System Integration Example

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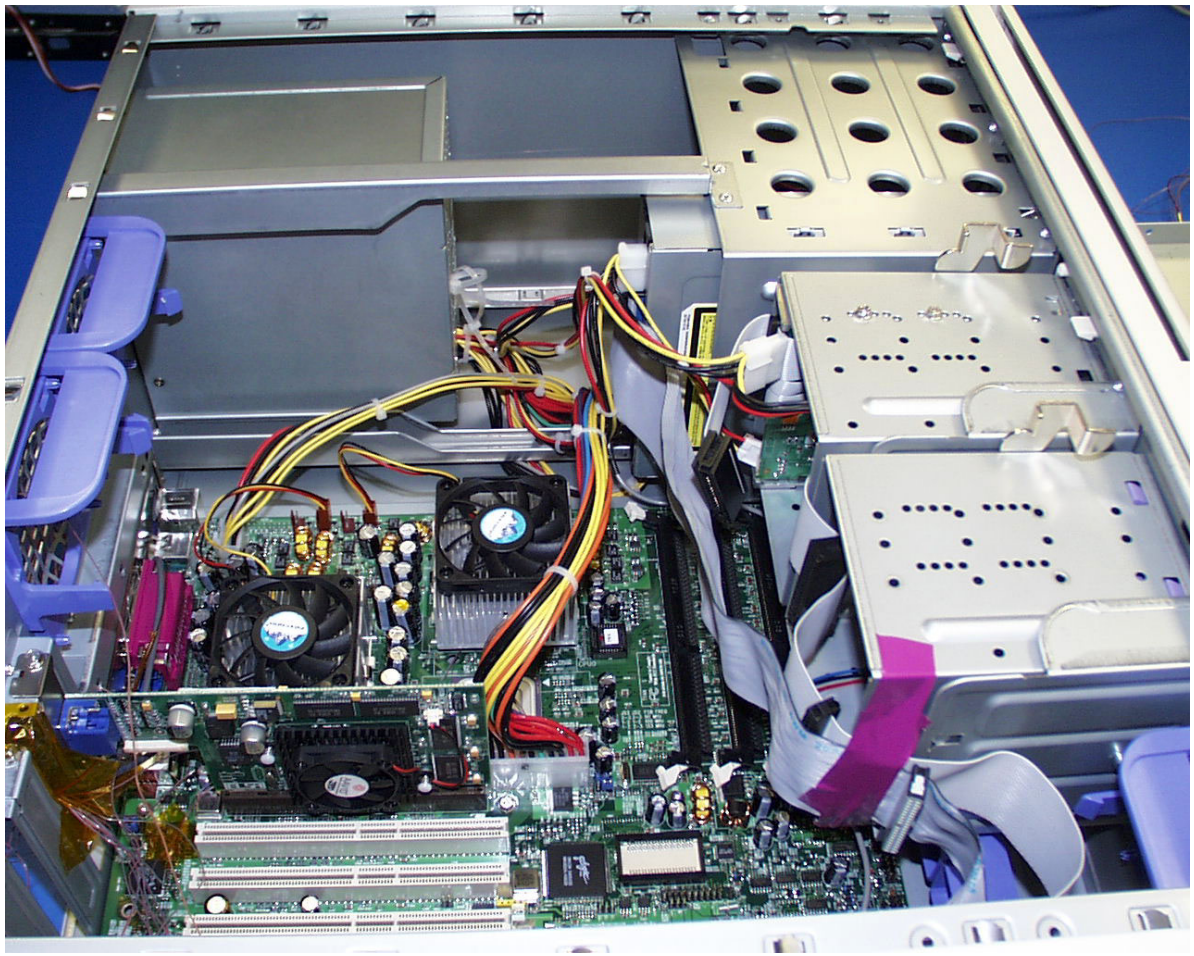
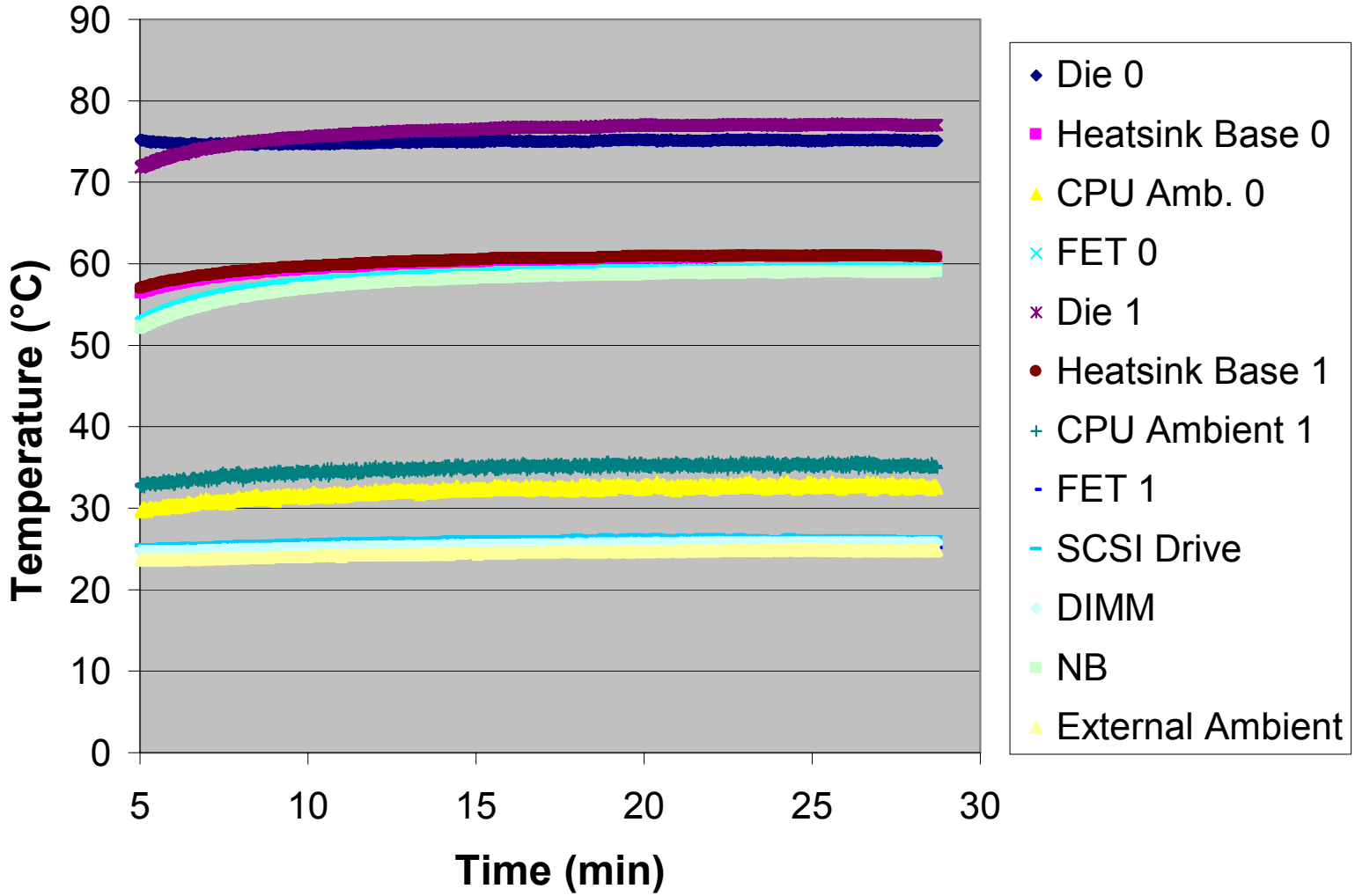
Tower Chassis—2P System Configuration

- System configuration
  - Processors: 1400 Mhz AMD Athlon™ MP processors
  - Motherboard: Tyan Thunder
  - Power supply: Delta 460W
  - SCSI drives: Quantum Atlas 9GB
  - Video card: Elsa Gloria II
  - Memory: 1024MB Samsung PC2100
  - DVD drive: Toshiba SD-M1402
  - Floppy disk drive: TEAC FD-235HF
  - Sound card: Sound Blaster Live
  - Tower chassis: ChenMing, Chenbro or Palo Alto

System Configuration Tested—ChenMing



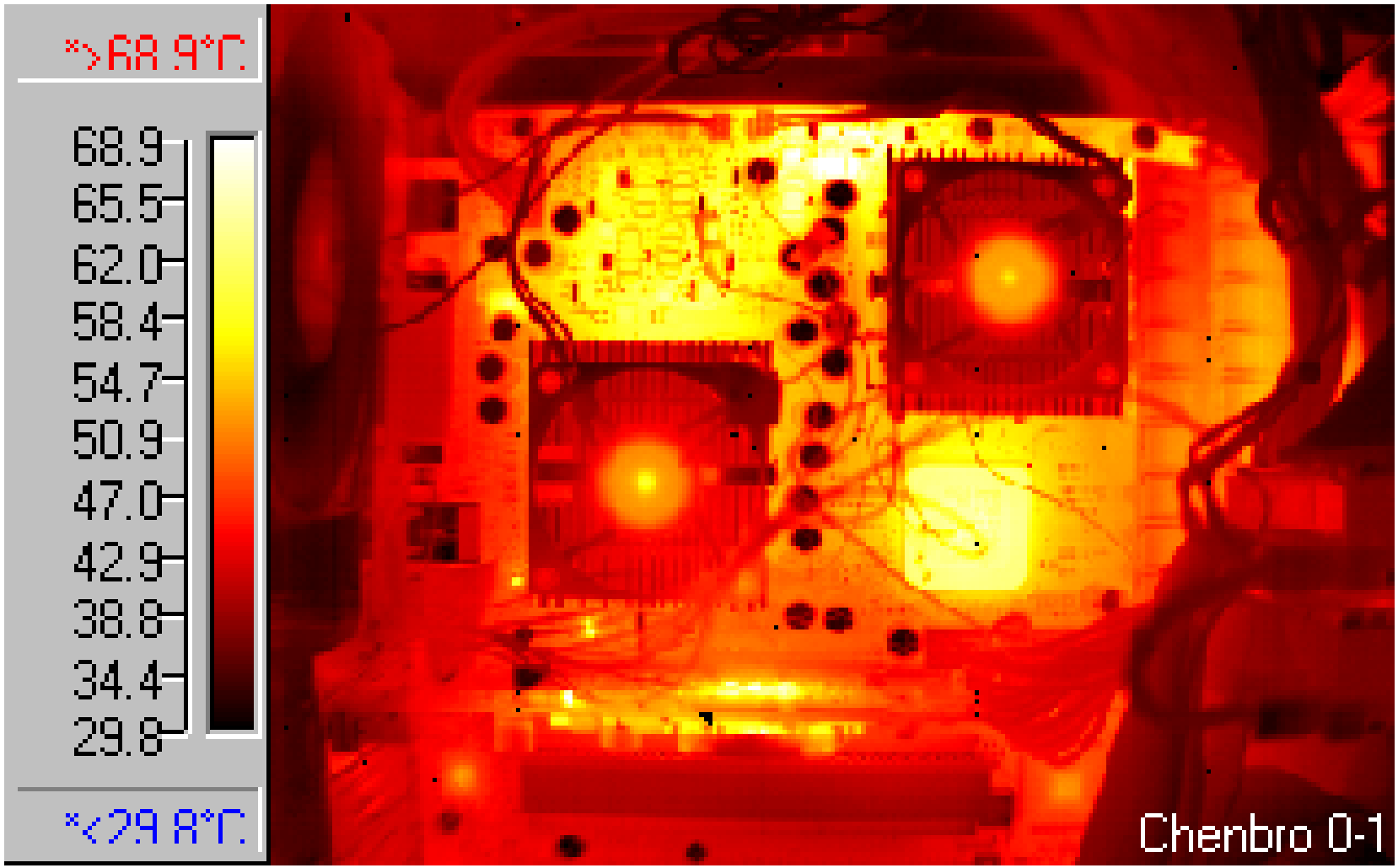
Measurements from ChenMing Test



Thermal Characterization Results

- Test Conditions
  - Dual processor mode running two instances of "BurnK6"—1400 MHz AMD Athlon™ MP processors
  - Foxconn PK0453AEDAUFB aluminum/copper heatsinks utilized
  - Optimal performance obtained with one 80-mm system fan located in front of chassis
- ChenMing Results
  - Supports dual AMD Athlon™ MP processor-based 1200-MHz system with above configuration
  - Rear processor --> processor 1 is always highest temperature
- Further optimization required to support beyond 1200 MHz

IR Image of Motherboard in Chenbro Chassis



Chenbro Thermal Characterization

- Test conditions
  - Dual processor mode running two instances of "BurnK6"—1400-MHz AMD Athlon™ MP processors
  - Foxconn PK0453AEDAUFB aluminum/copper heatsinks utilized
  - Optimal performance obtained with one 80-mm front system fan and one 80-mm rear system fan
- Chenbro Results
  - Supports dual AMD Athlon™ MP processor 1000-MHz system with above configuration
  - Rear processor --> processor 1 is always highest temperature
- Further optimization required to support beyond 1000 MHz

Palo Alto Thermal Characterization

- Test conditions
  - Dual processor mode running two instances of "BurnK6"—1400-MHz AMD Athlon™ MP processors
  - Foxconn PK0453AEDAUFB aluminum/copper heatsinks utilized
  - Optimal performance obtained with one 90-mm system fan in front and one 120-mm fan in rear of chassis
- Palo Alto Results
  - Support a dual 1200-MHz system
  - Rear processor --> processor 1 is always highest temperature
- Further optimization required to support beyond 1200 MHz

Future Development Focus

- Efforts to improve frequency support:
  - Ducting
  - Heatsinks with different fin orientation
- Efforts to improve heatsink testing:
  - Speed controlled fans to reduce noise at room temperature
  - Ducting to eliminate need for system fans

Recommendations for Dual AMD Athlon™ MP Processor-Based Systems in 1U Rack Mounted Form Factor

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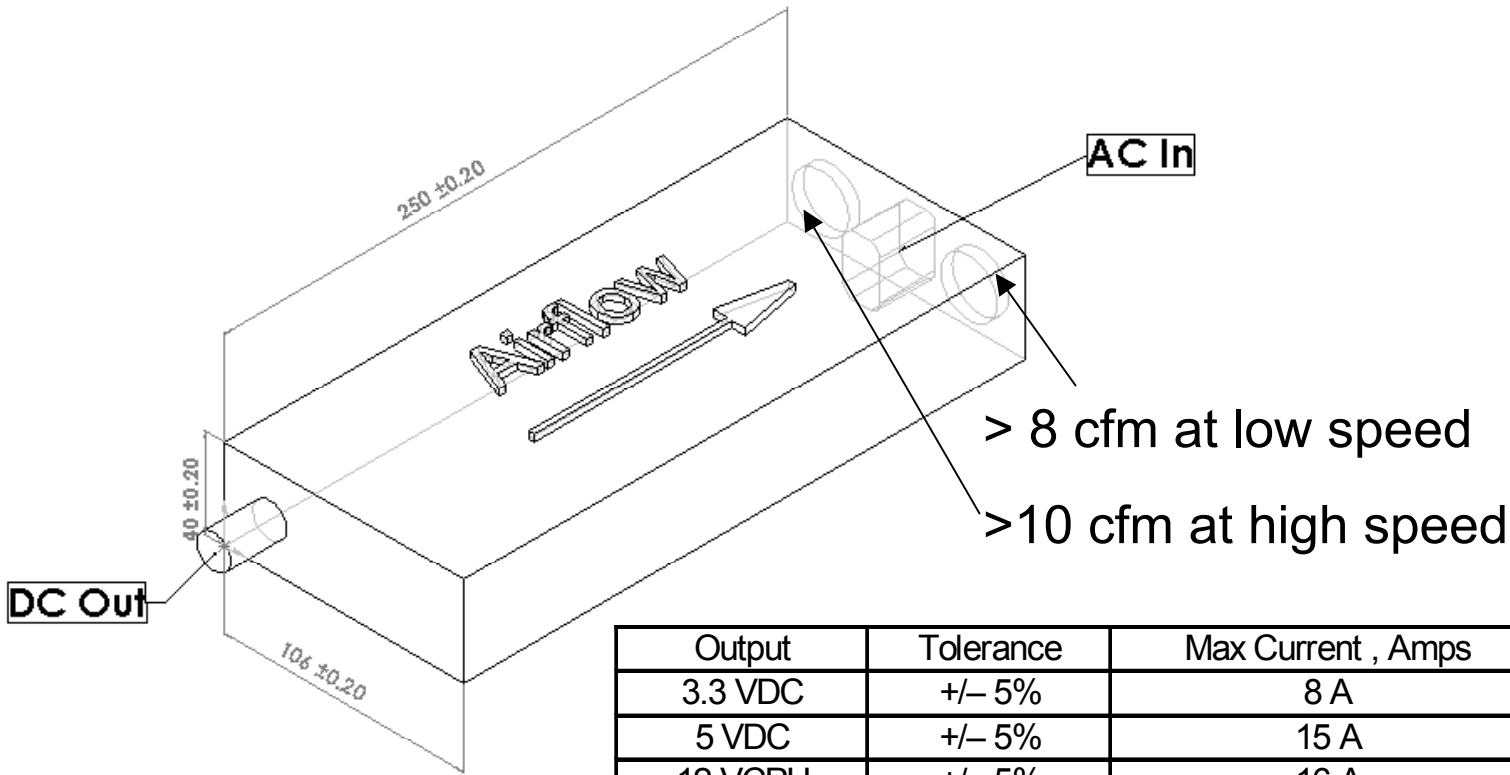
Thermal Design Approach for Dual AMD Athlon™ MP Processor-Based Systems in 1U Form Factor

- Layout motherboard utilizing keepout region definition for single processor systems
- Drawer floorplan is custom for the motherboard. Recommended floorplan is described using Tyan Thunder motherboard
- Utilize a single heat sink per processor
  - Heat sink is coupled to blower placed in close proximity to the board
  - Utilizes low profile extrusions used for desktop without dedicated fan on heat sinks
- Power supplies specification in review with development partners

Reference Design 1U Power Supply Requirements

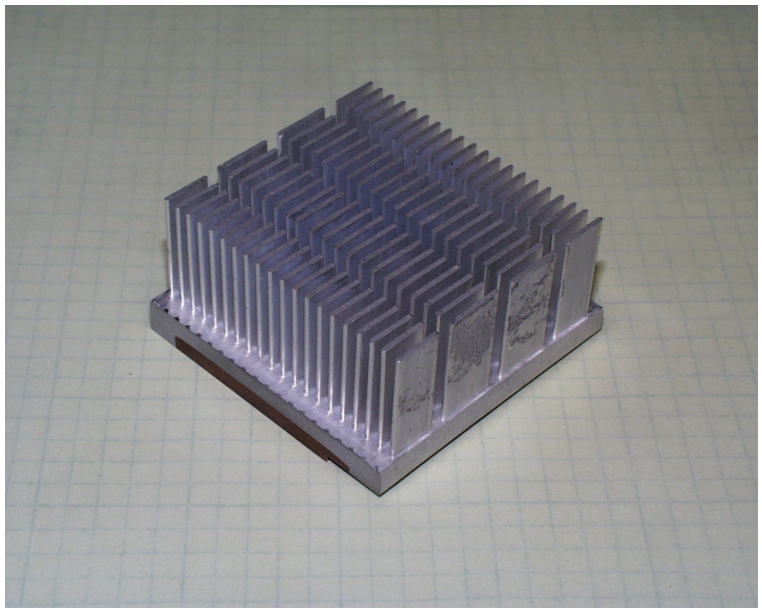


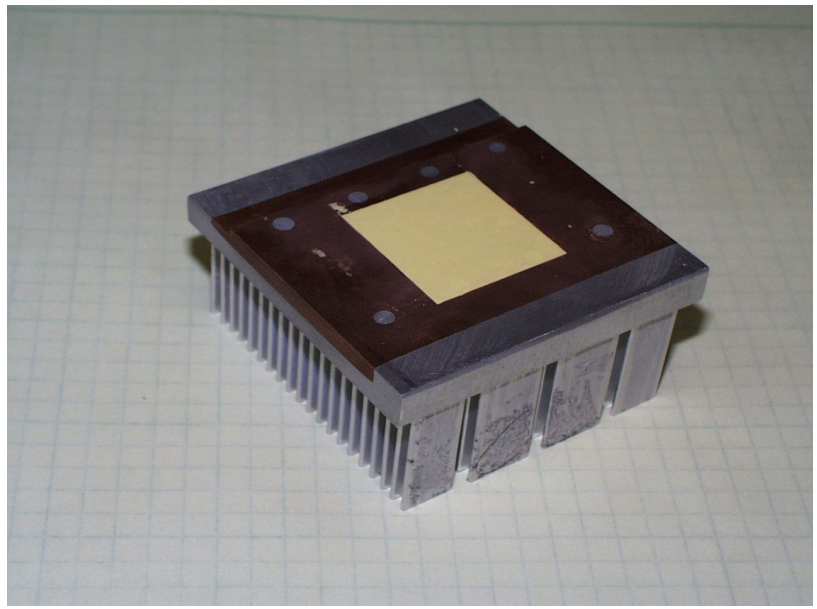
Output	Tolerance	Max Current , Amps
3.3 VDC	+/– 5%	8 A
5 VDC	+/– 5%	15 A
12 VCPU	+/– 5%	16 A
12 VIO	+/– 5%	5A (7A Peak)
–12 VDC	+/–10%	0.8 A
5 VR	+/– 5%	2.0 A

Heat Sinks for Dual Processor Implementations in 1U Form Factor

- Address thermal design at the drawer layout/floor plan level
  - Low-profile fan sinks do not have sufficient pressure/flow characteristics for this form factor.
  - Standard 1U designs that have a simple front-to-back flow distribution do not provide adequate cooling.
  - Custom floor plan utilizing higher pressure/flow blowers for cooling the processor is required to support entire roadmap
- IMPORTANT: Entire floor plan evaluated to assess performance
  - Ducting and blowers
  - Cooling provided to drives, memory, and power supply
- Temperature specification guidelines
  - Maximum external system ambient = 35°C
  - Power dissipation is at the maximum specification
  - Die temperature $\leq$ maximum specification

Example Heat Sink Used in Reference Design



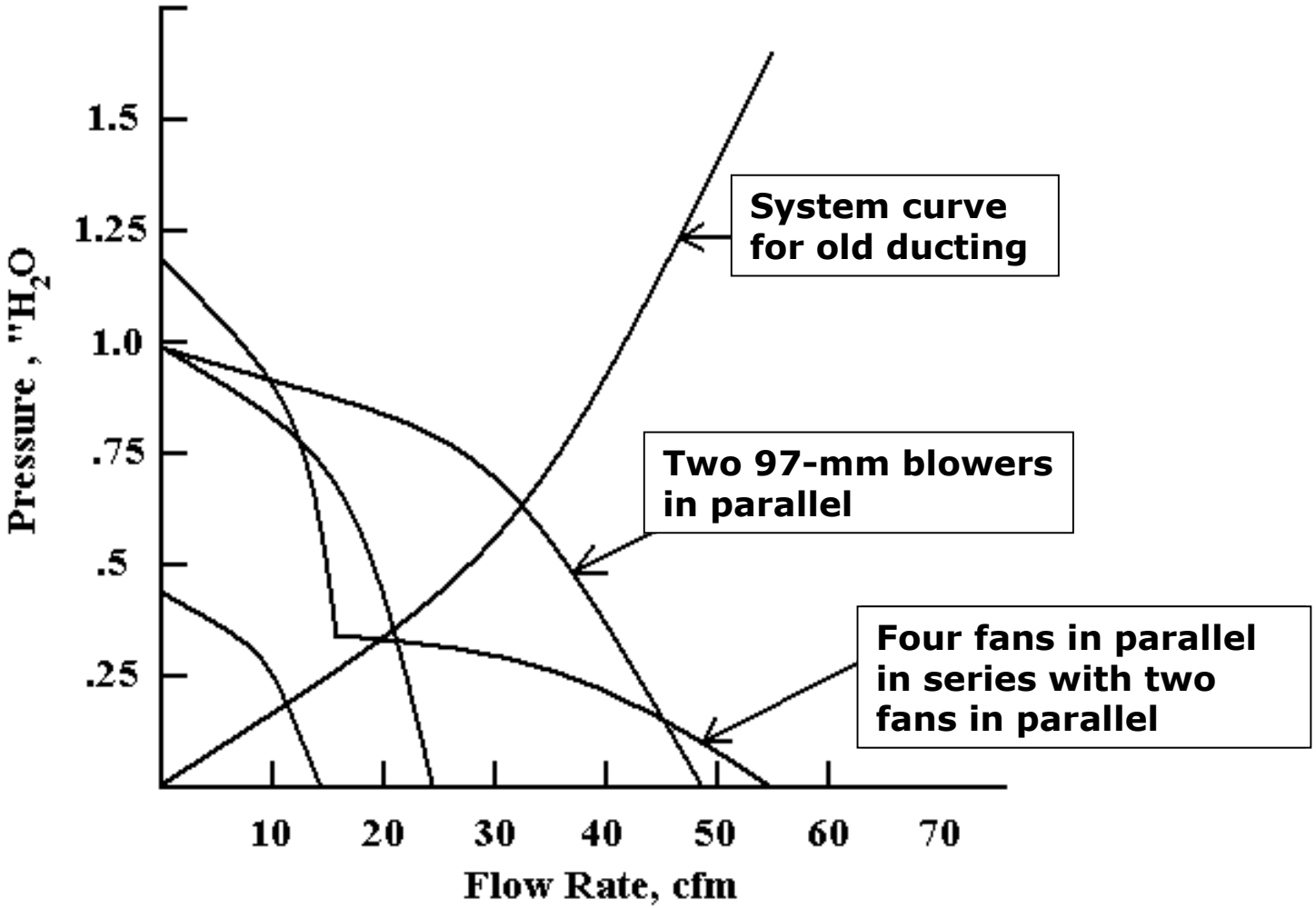


- **Base:** **60mm width x 60mm depth x 7.5mm thickness**
- **Cu slug:** **45mm width x 60mm depth x 4mm thickness**
- **Fin:** **22.6mm height x 0.92mm width x 2.04mm spacing**
- **Crosscuts:** **3.05mm wide**
- **Thermal interface material:** **Thermagon TCP 905c**

Example 97-mm Blowers Used in 1U Reference Design

- Nidec Model #A34124-16
  - 0.65A @ 12V
  - 23 cfm at 0” H_2O
  - 0.95” of H_2O at 0 cfm
- Delta Model# BFB1012 H
  - 1.2A @ 12V
  - 25 cfm at 0” H_2O
  - 1.0 ” of H_2O at 0 cfm
- Both blowers have been used with comparable results.

Matching Air Movers to System Resistance

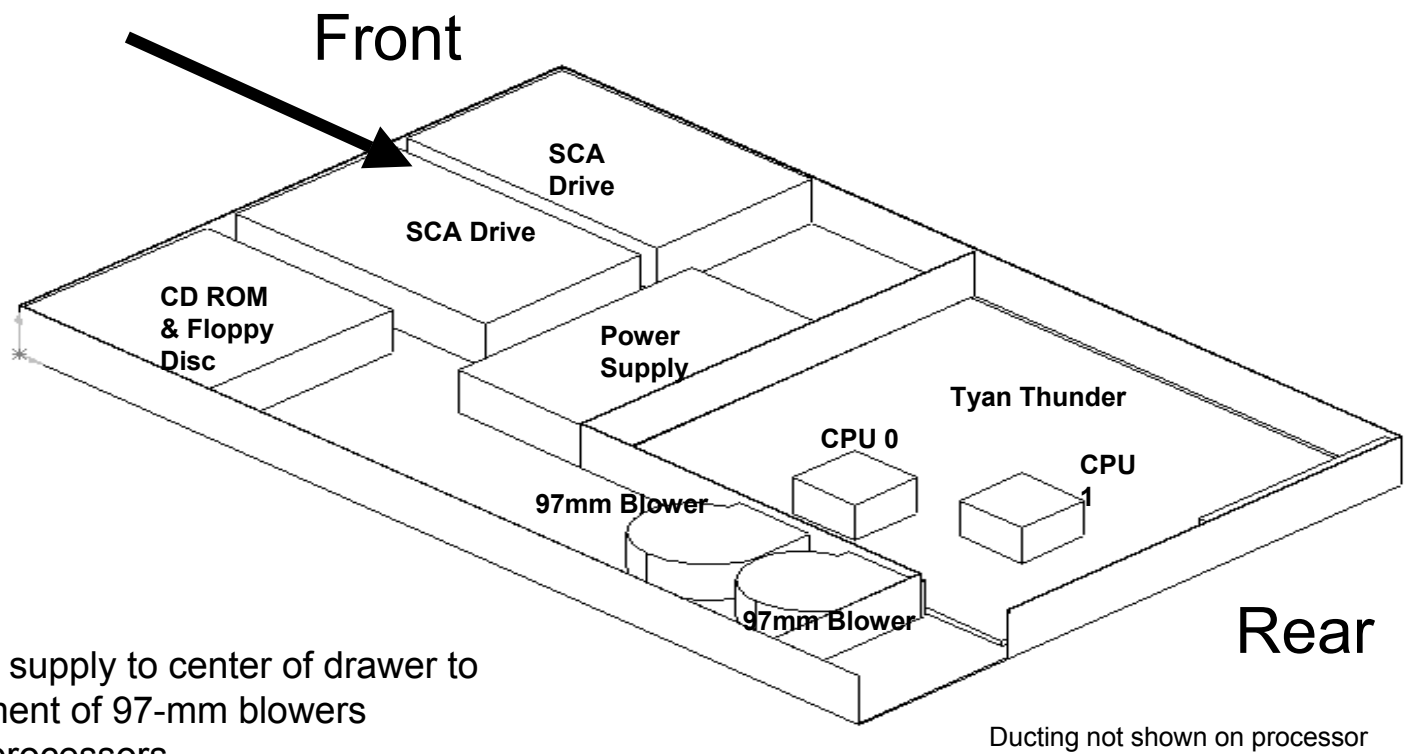


1U System Integration Example

1U System Configuration

- System Configuration
  - Processors: 1200 MHz AMD Athlon™ MP
  - Motherboard: Tyan Thunder
  - Power supply: In development
  - SCSI drives: Quantum Atlas 10KII 18.4B
  - Onboard video card: ATI Rage 128
  - Memory: 1024Mb Samsung PC2100
  - CD drive: Toshiba XM-1902B
  - Floppy disk drive: TEAC FD-235HF
  - 1U server chassis: Computer and Control Solutions

AMD Proposed Configuration



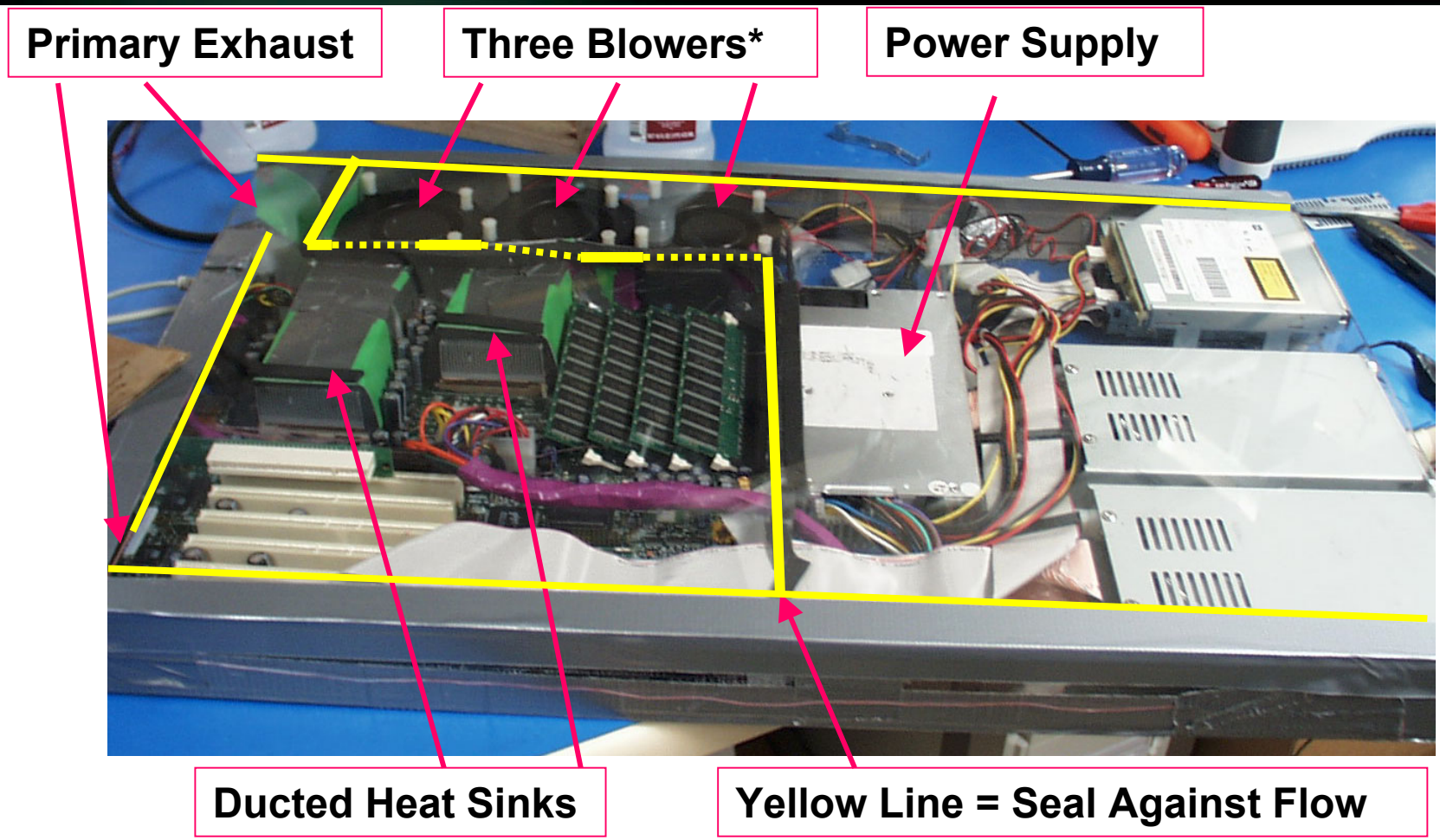
Ducting not shown on processor

Place power supply to center of drawer to allow placement of 97-mm blowers adjacent to processors.

Utilize drawer length of 27”–28”.

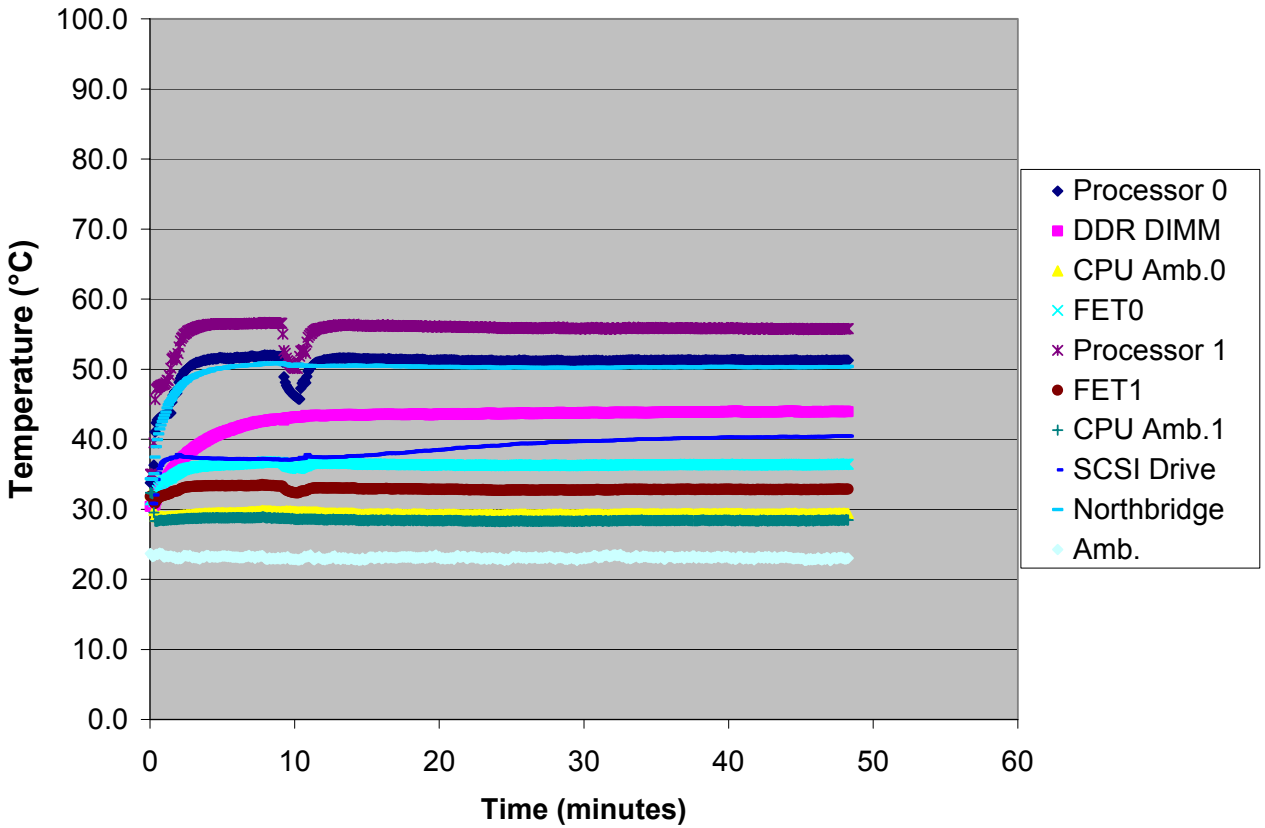
Duct flow from blowers directly to processor locations.

Reference Floor Plan in Lexan Chassis



*Reduced to two blowers in the final configuration.

Temperature Measurements in 1U Floorplan



- Measured using 800-MHz AMD Athlon™ processors
- 3°C per 100MHz --> ~1000 MHz of margin to 95°C specification

Test Data for Floor Plan Proposed by Floor Plan AMD

Configuration	CPU 0			CPU1		
	External Temp.	θ_{JA} C/W	MHz at 35°C amb	External Temp.	θ_{JA} C/W	MHz at 35°C amb
Lexan chassis, dual 800 AMD Athlon™ processors, Taisol 20 Fin 60x60 heatsinks, three NMB blowers, dual 18G SCA drives	**4.3**	**0.666**	**1800**	**4.2**	**0.806**	**1500**
Lexan chassis, dual 800 AMD Athlon™ processors, Taisol 20 Fin 60x60 heatsinks, two NMB blowers, dual 18G SCA drives	**6.5**	**0.595**	**2000**	**5.6**	**0.762**	**1600**

- Floor plan covers up to 1600-MHz AMD Athlon™ MP processors
- Optimization being performed to push the performance higher

Future Development Focus

- Blower selection
- Optimization of pressure drops in ducting
- Optimizing heat sinks—Select fin density to match blower characteristics.
- Optimize the air flow path through the drawer to reduce the number of turns, expansions, and contractions.

Summary

- 2P Tower form factor
  - Three systems tested and validated
    - Chenbro—Qualified through 1000 MHz
    - ChenMing—Qualified through 1200 MHz
    - Palo Alto—Qualified through 1200 MHz
  - Further work ongoing to improve frequency coverage of above systems
- 1U form factor
  - Reference design developed
  - Working with system and chassis suppliers for enabled solutions

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