



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

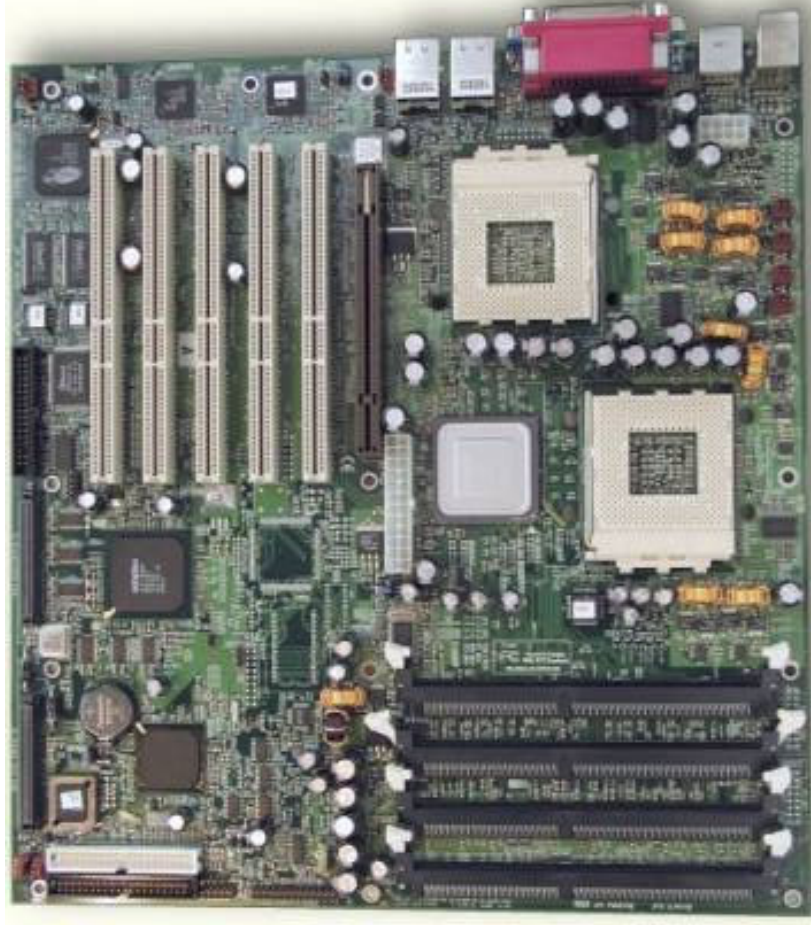
Outline



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 - Heat sinks
 - Thermal test results
- **Summary**

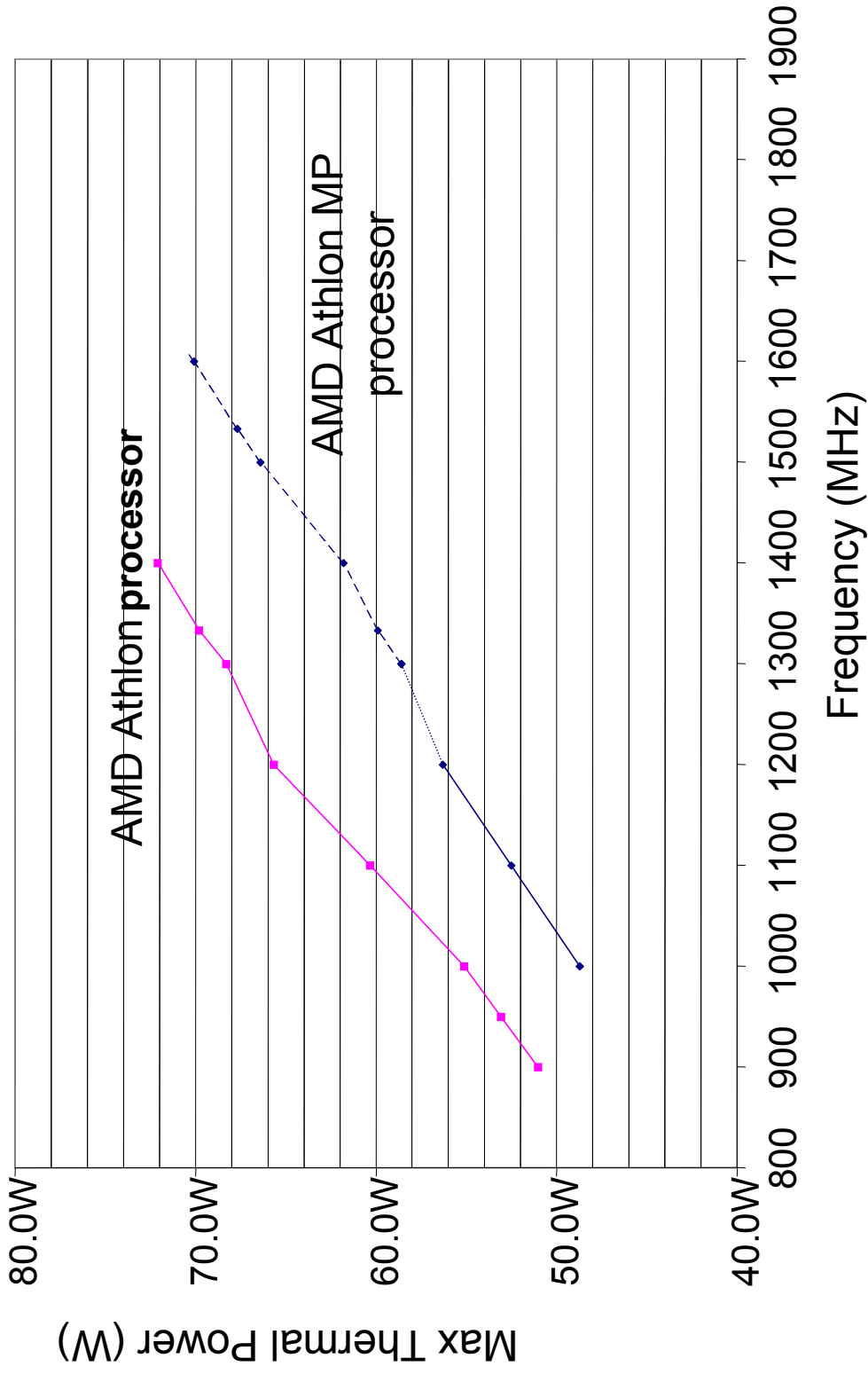
Introduction



- **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

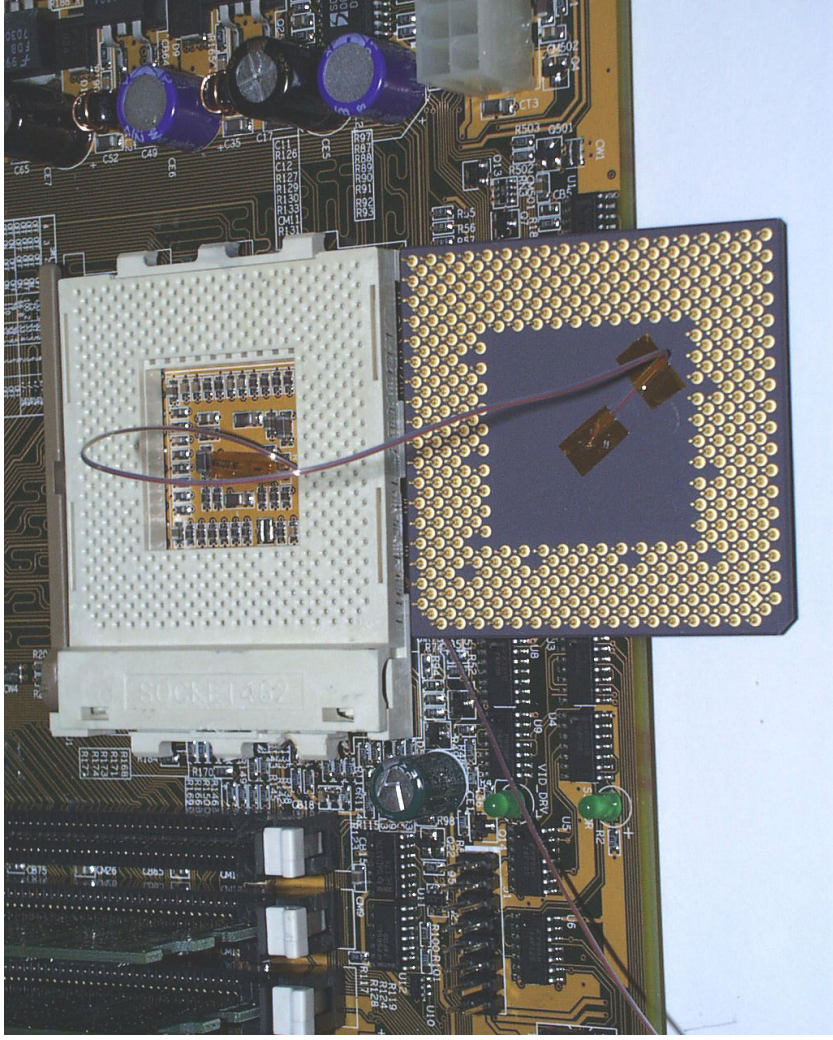
Test Methodology (...cont.)



- 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)

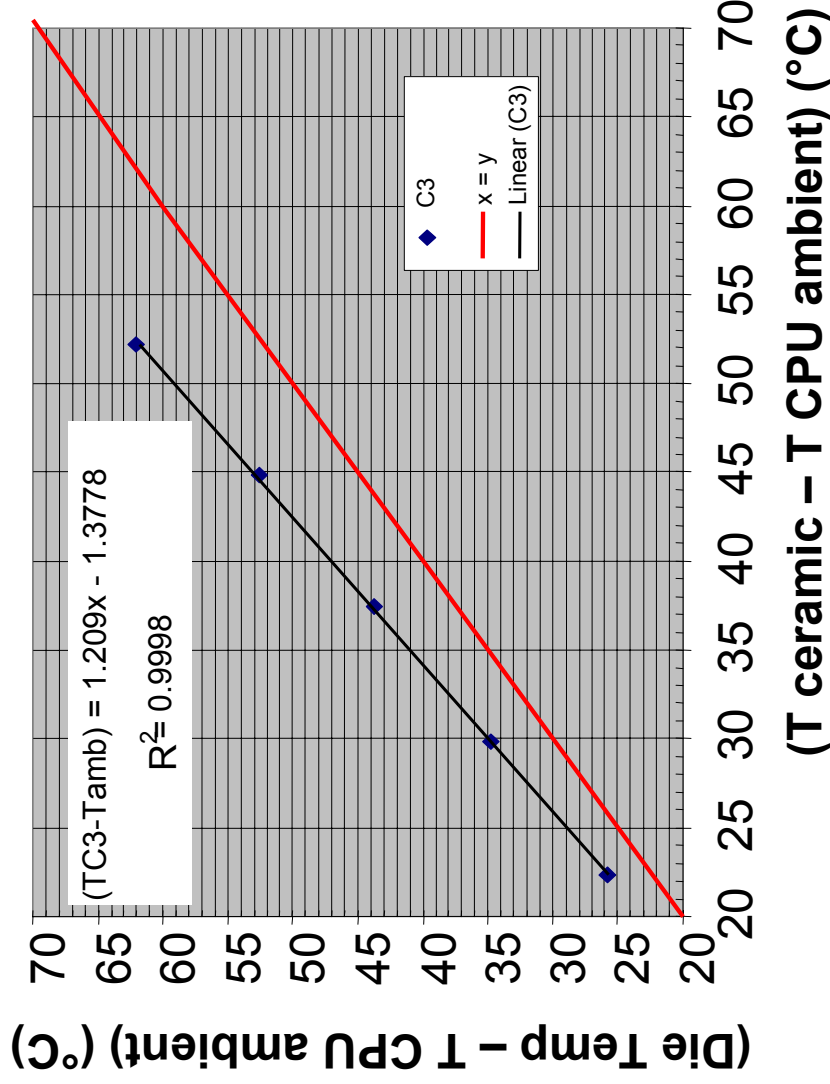
Indirect Temperature Measurement Method **AMD**

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- 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: $\pm 2^\circ\text{C}$ for centered clip

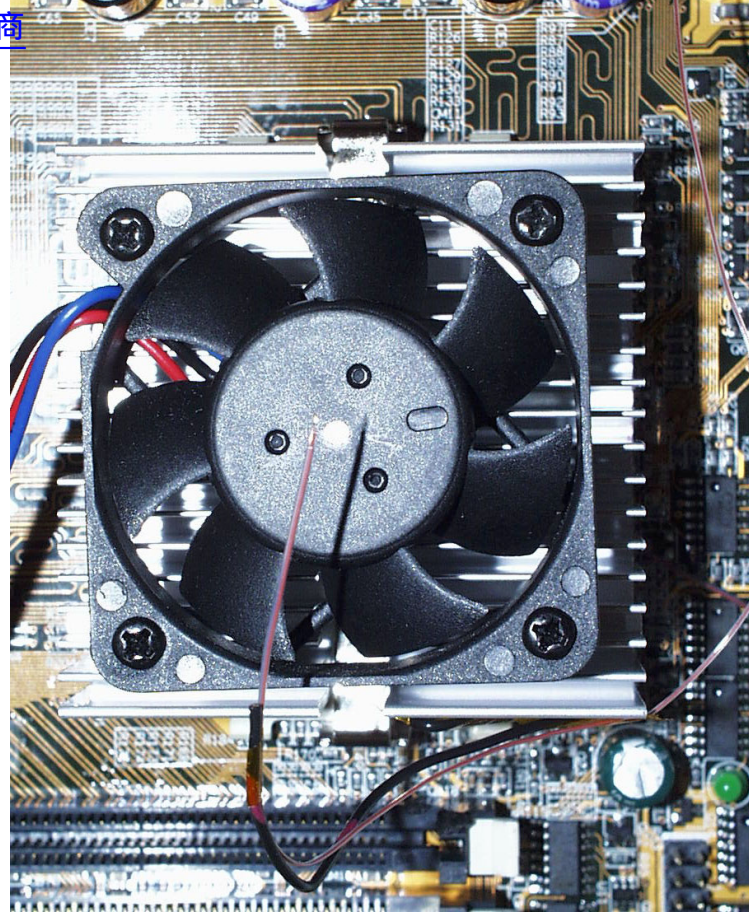
- Correlation relates die temperature to backside ceramic temperature
- Referenced to local CPU ambient
- Measurements performed on a thermal test vehicle
- Power varied to create correlation
- Validated against multiple, more involved methods of making temperature measurement

CPU Ambient Thermocouple

AMD

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- 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

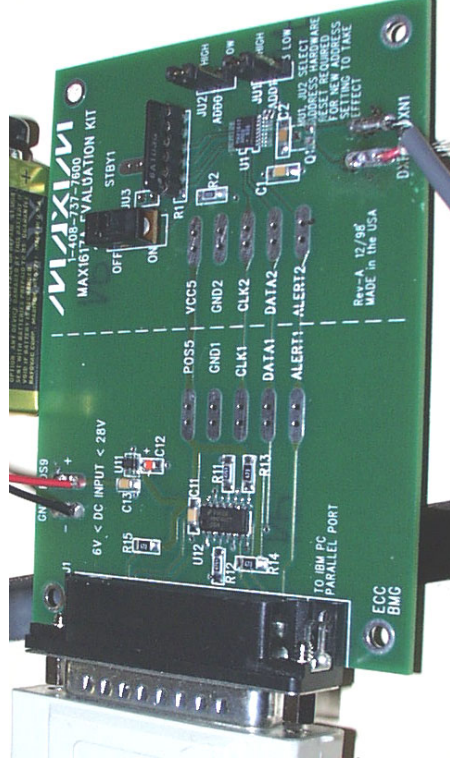


Evaluation Temperature Sensor Kits

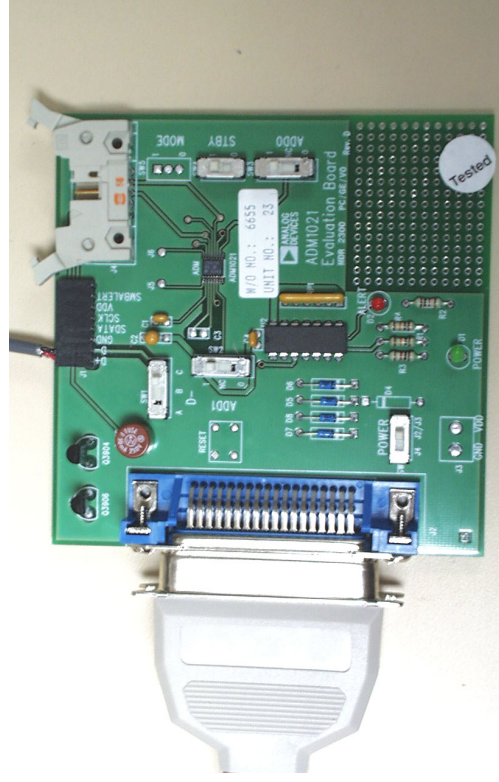


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- Maxim 1617A Evaluation Kit



- Analog 1021A Evaluation Kit



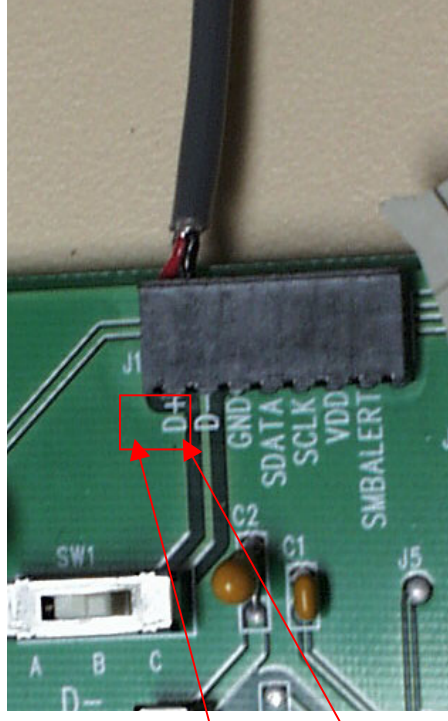
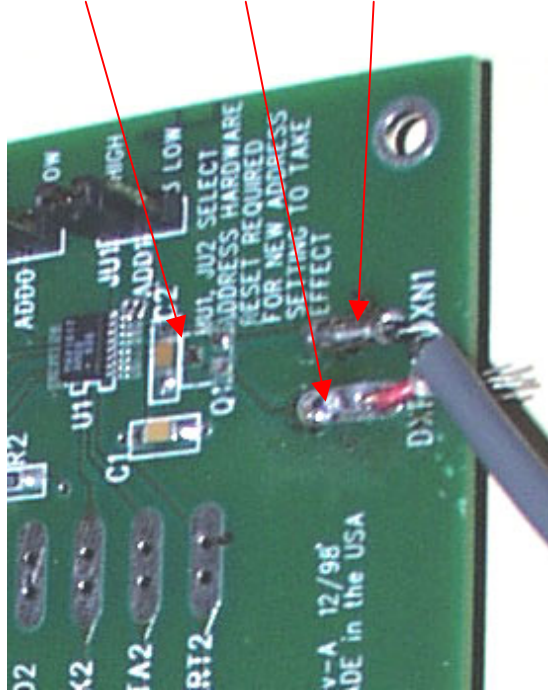
Connect to the On-Die Temperature Diode **AMD**

- 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

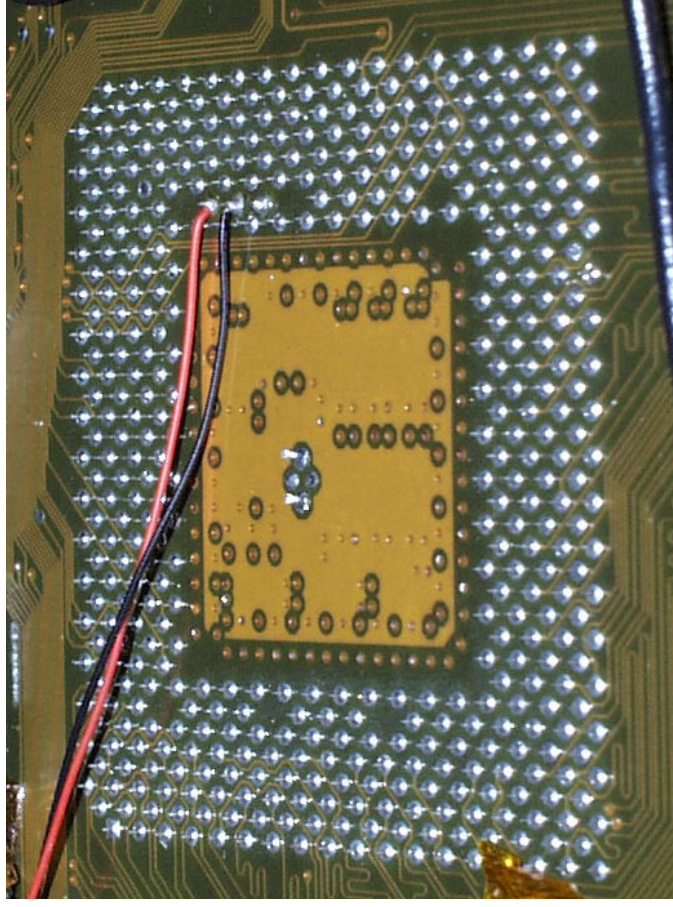
Negative
terminal





Connect to Vcc Core Feedback Pins

- Connect 30-gauge 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:
 - $(T_{die} - T_{amb}) = 1.209 \times (T_{ceramic} - T_{amb}) - 1.3778$
- θ_{js} and θ_{sa} calculated
- Maximum Allowable Power (MAP) at 35°C calculated:
 - $MAP = (90^\circ\text{C} - T_{amb}) / \theta_{ja}$
- Projected die temperature calculated:
 - $T_{die} = \text{Power (from MTP table)} \times \theta_{ja} + T_{amb}$

- 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

Thermal Design for Dual AMD Athlon™ MP AMD

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



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*Will present test results

Heat Sinks for Dual Processor Implementations in Tower Form Factor



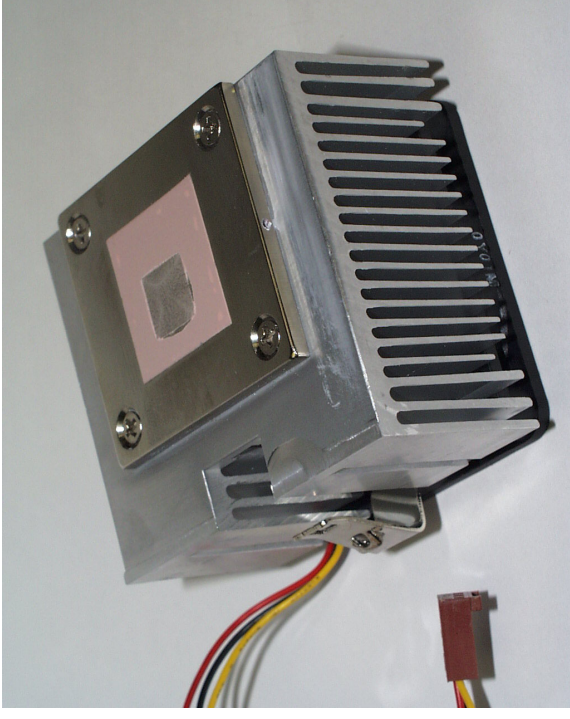
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- Use standard single processor desktop heat sinks.
- Heat sink frequency rating is based on the following criteria:
 - Maximum external system ambient = 35°C
 - External-to-internal temperature rise $\leq 14^{\circ}\text{C}$
 - Power dissipation is at the maximum specification.
 - Die temperature $\leq$ 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



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- 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



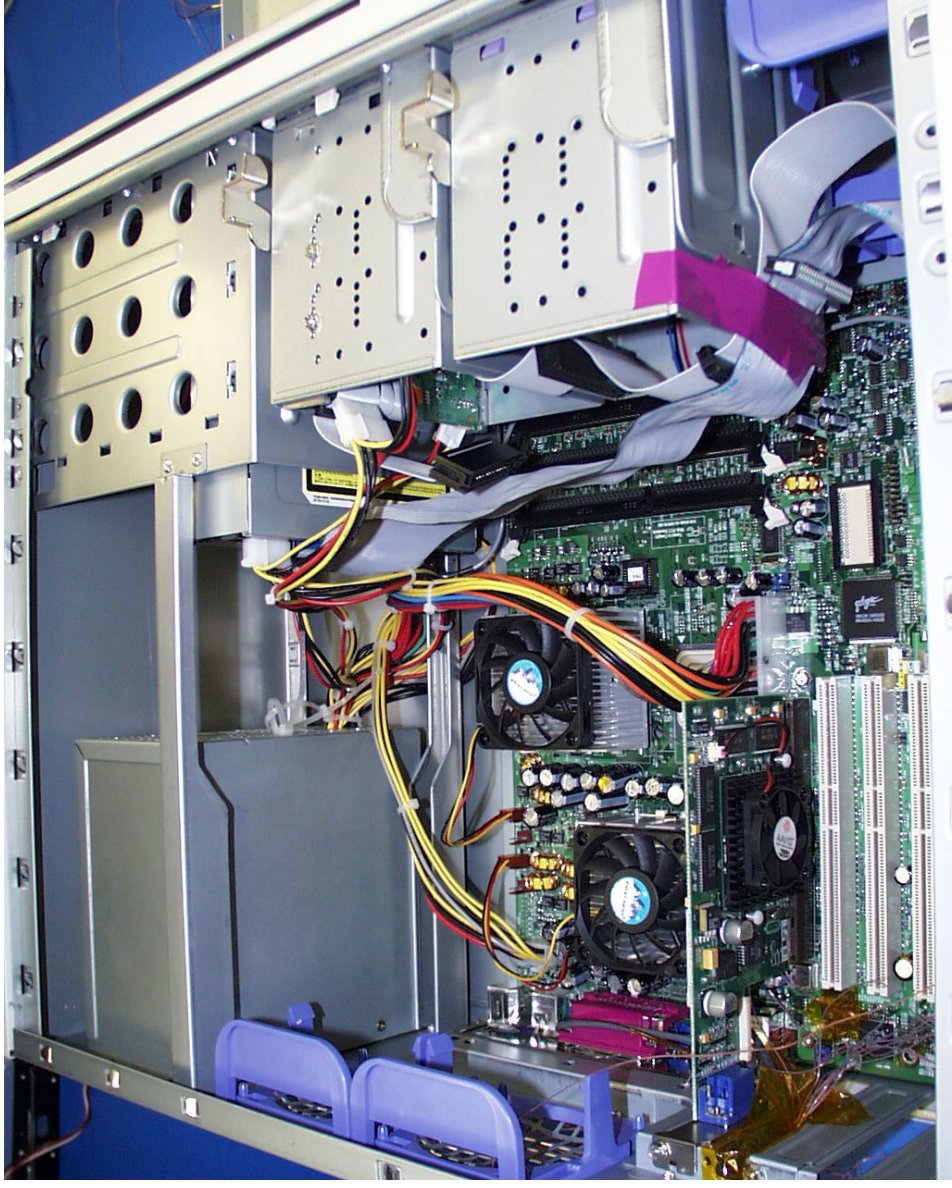
Tower Chassis—2P System Configuration

- System configuration

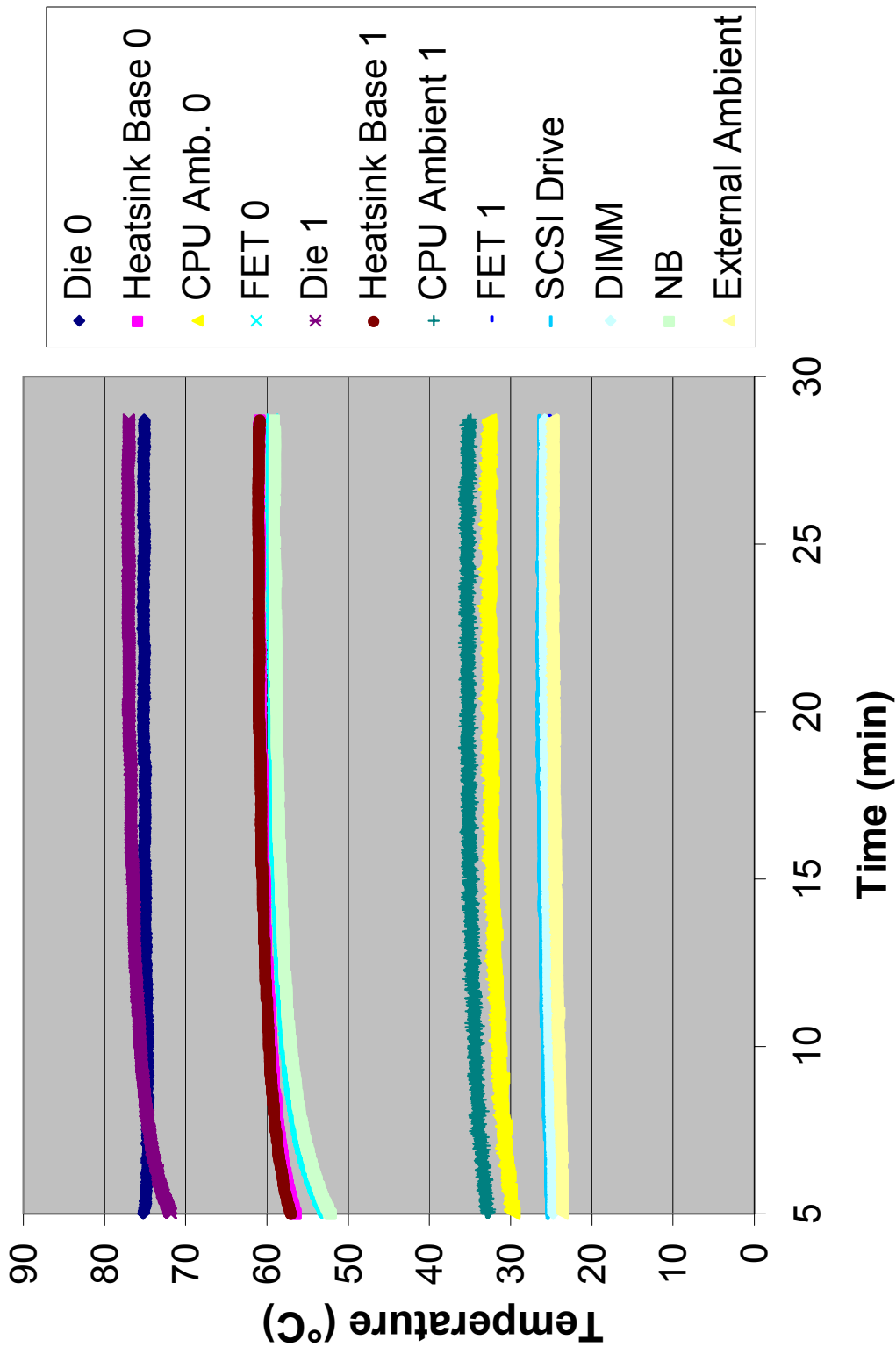
- Processors: 1400 Mhz AMD Athlon™ MP processors
- Motherboard: Tyan Thunder
- Power supply: Delta 460W
- SCSI drives: Quantum Atlas 9GB
- Video card: Elsa Gloria II
- Memory: 1024MB Samsung PC2100
- DVD drive: Toshiba SD-M1402
- Floppy disk drive: TEAC FD-235HF
- Sound card: Sound Blaster Live
- Tower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



System Configuration Tested—ChenMing



Measurements from ChenMing Test



Thermal Characterization Results



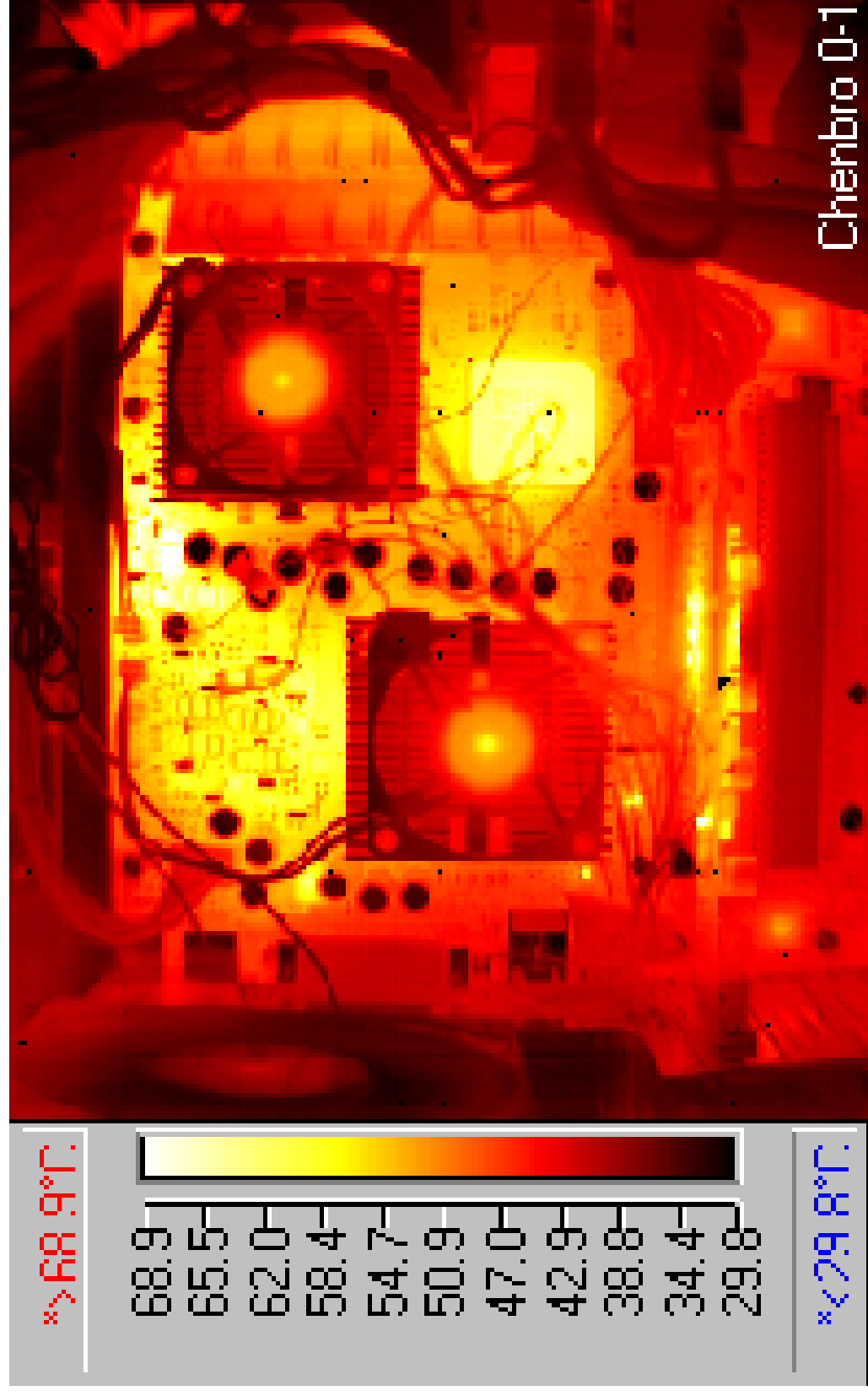
- Test Conditions

- 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



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- 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



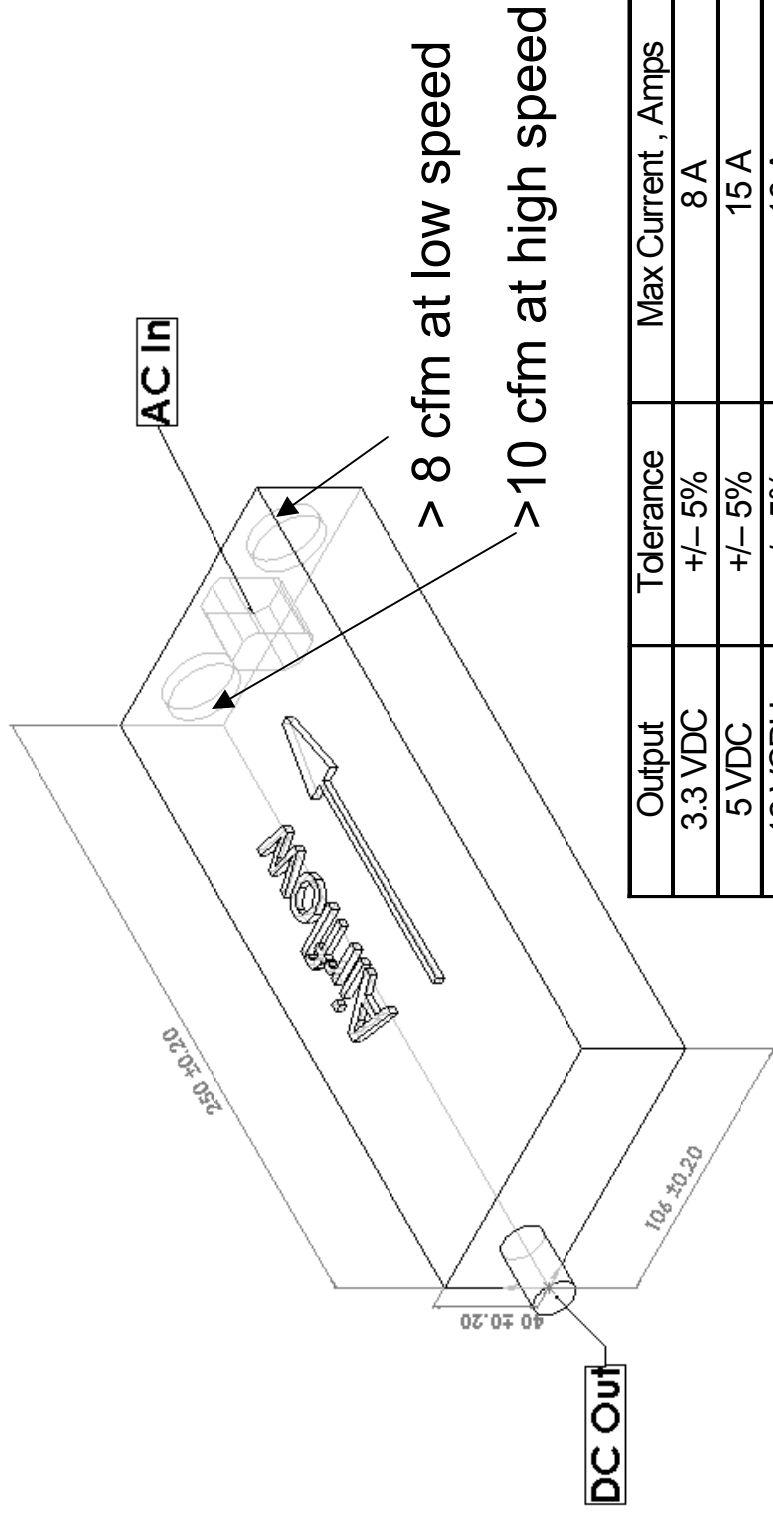
Recommendations for Dual AMD Athlon™ MP Processor-Based Systems in 1U Rack Mounted Form Factor

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



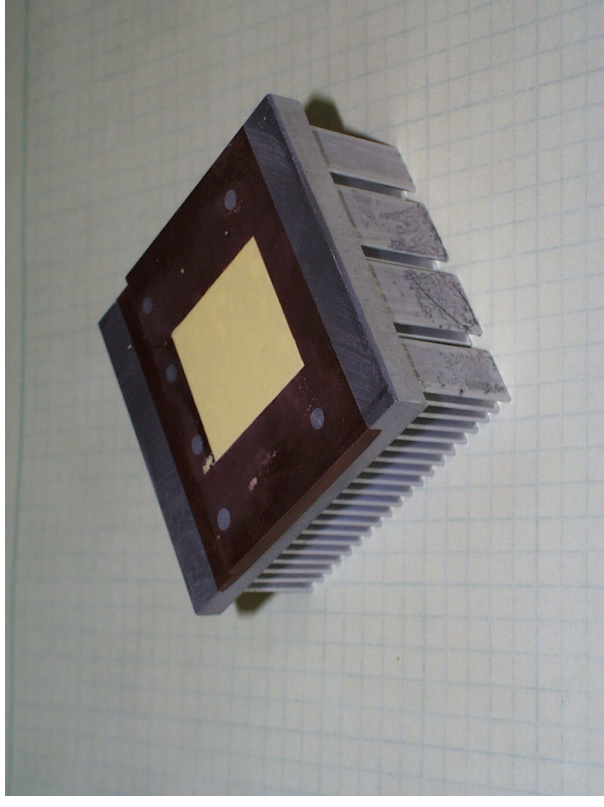
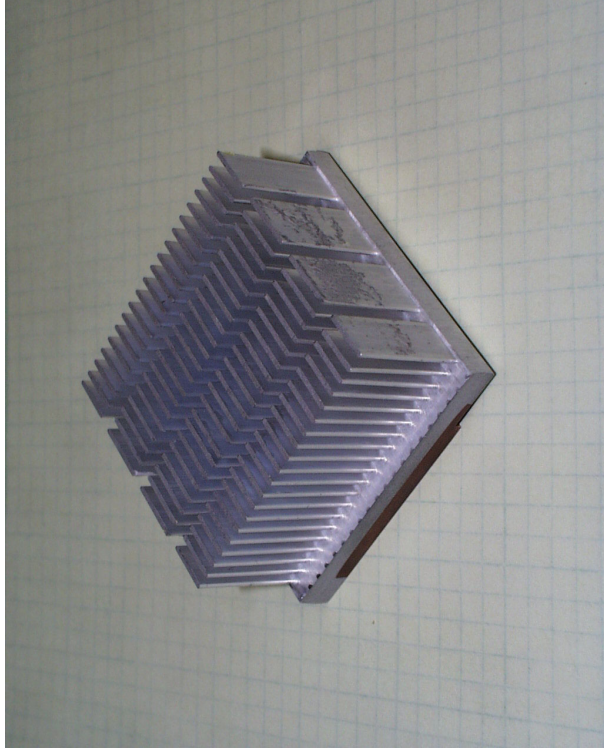
Output	Tolerance	Max Current , Amps
3.3 VDC	+/- 5%	8 A
5 VDC	+/- 5%	15 A
12 VCPU	+/- 5%	16 A
12 VIO	+/- 5%	5A (7A Peak)
-12 VDC	+/-10%	0.8 A
5 VR	+/- 5%	2.0 A

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



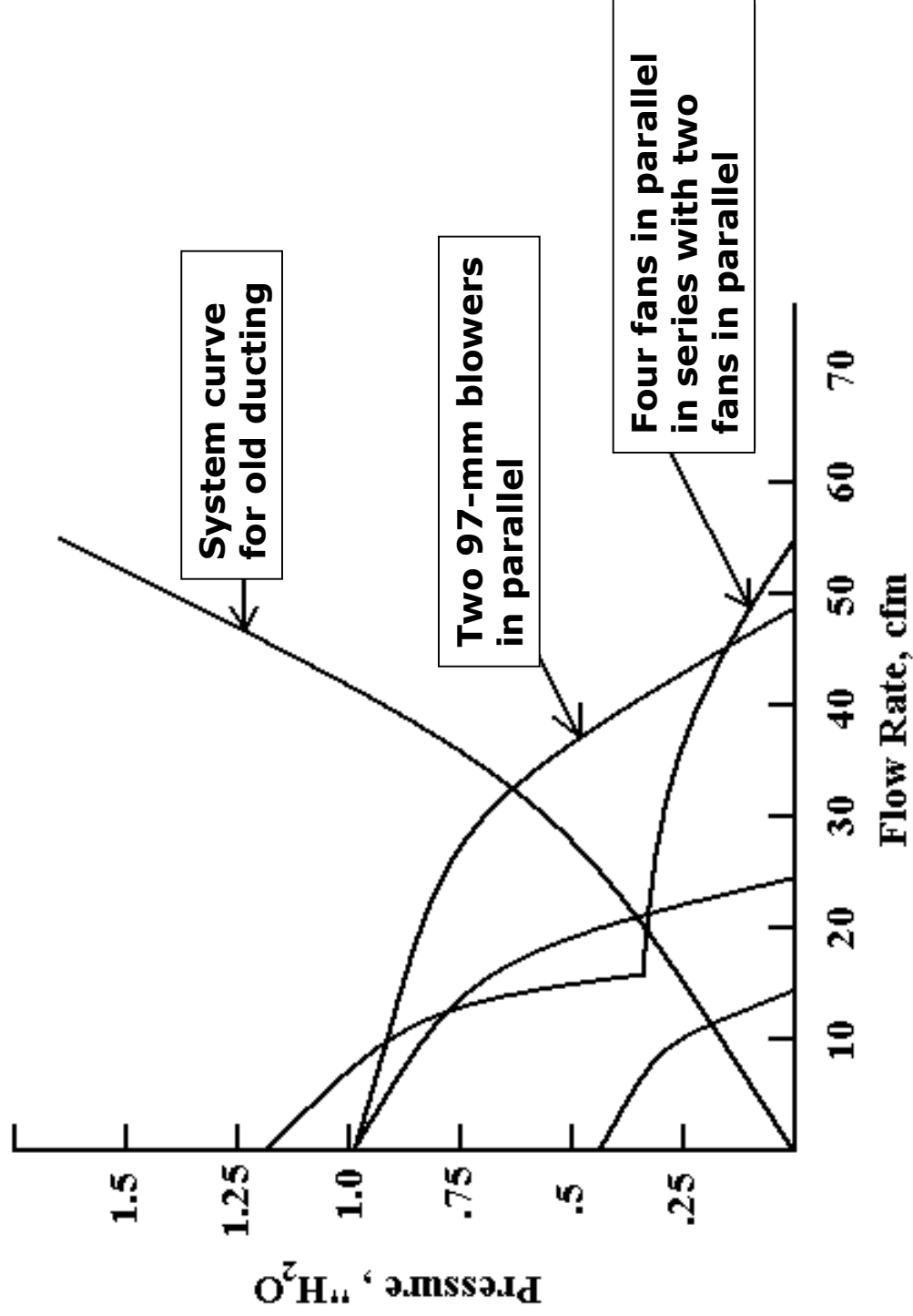
- **Base:** 60mm width x 60mm depth x 7.5mm thickness
- **Cu slug:** 45mm width x 60mm depth x 4mm thickness
- **Fin:** 22.6mm height x 0.92mm width x 2.04mm spacing
- **Crosscuts:** 3.05mm wide
- **Thermal interface material:** Thermagon TCP 905c

Example 97-mm Blowers Used in 1U Reference Design



- Nidec Model #A34124-16
 - 0.65A @ 12V
 - 23 cfm at 0" H₂O
 - 0.95" of H₂O at 0 cfm
- Delta Model# BFB1012 H
 - 1.2A @ 12V
 - 25 cfm at 0" H₂O
 - 1.0 " of H₂O at 0 cfm
- Both blowers have been used with comparable results.

Matching Air Movers to System Resistance **AMD**





1U System Integration Example

1U System Configuration

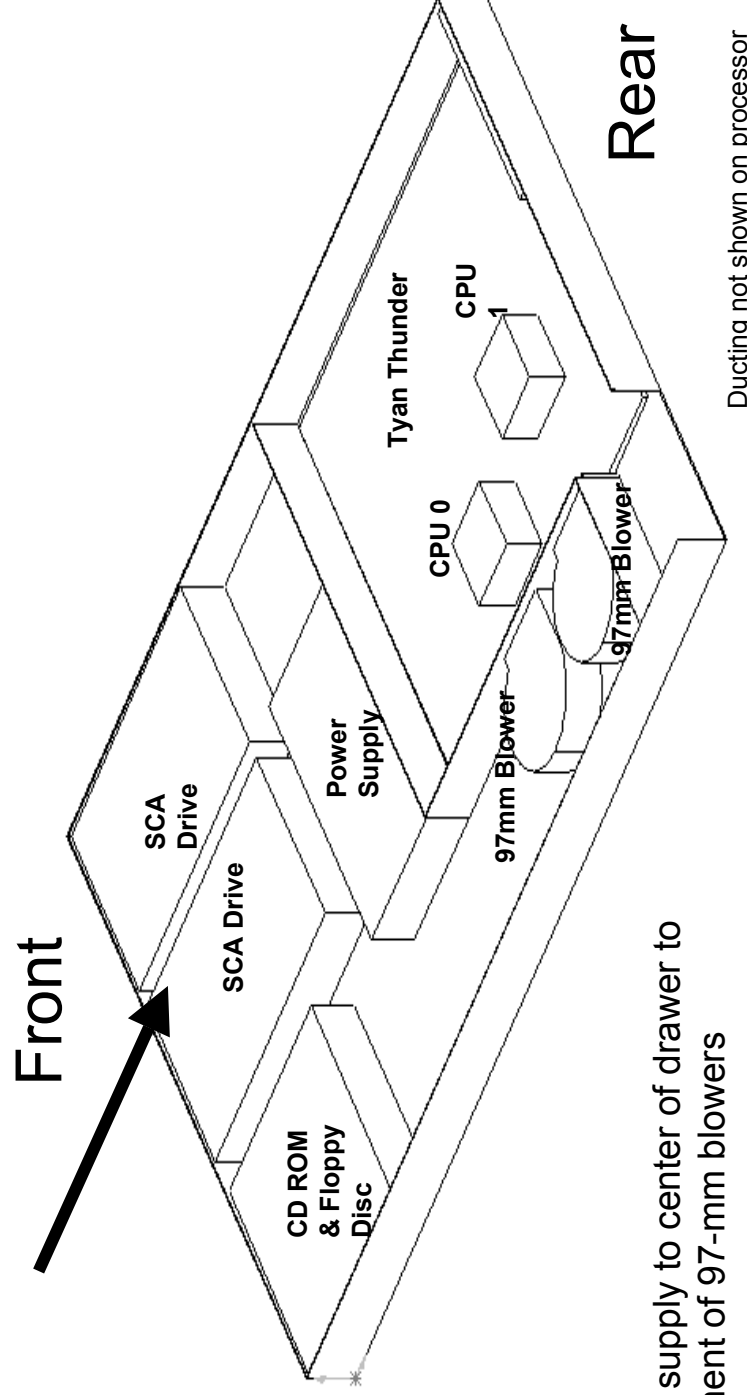


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- System Configuration

- 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



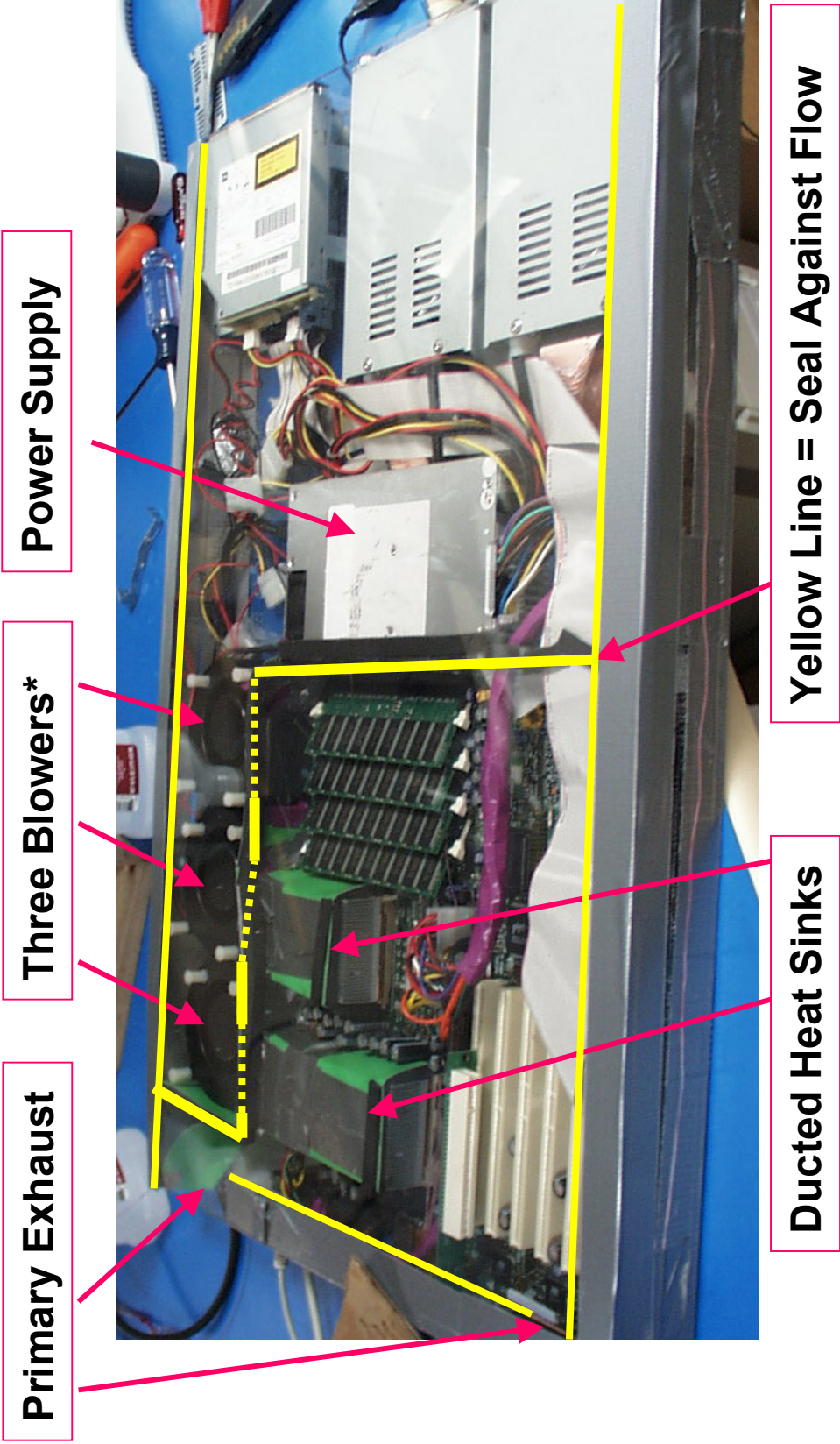
Place power supply to center of drawer to allow placement of 97-mm blowers adjacent to processors.

Utilize drawer length of 27"–28" .

Duct flow from blowers directly to processor locations.

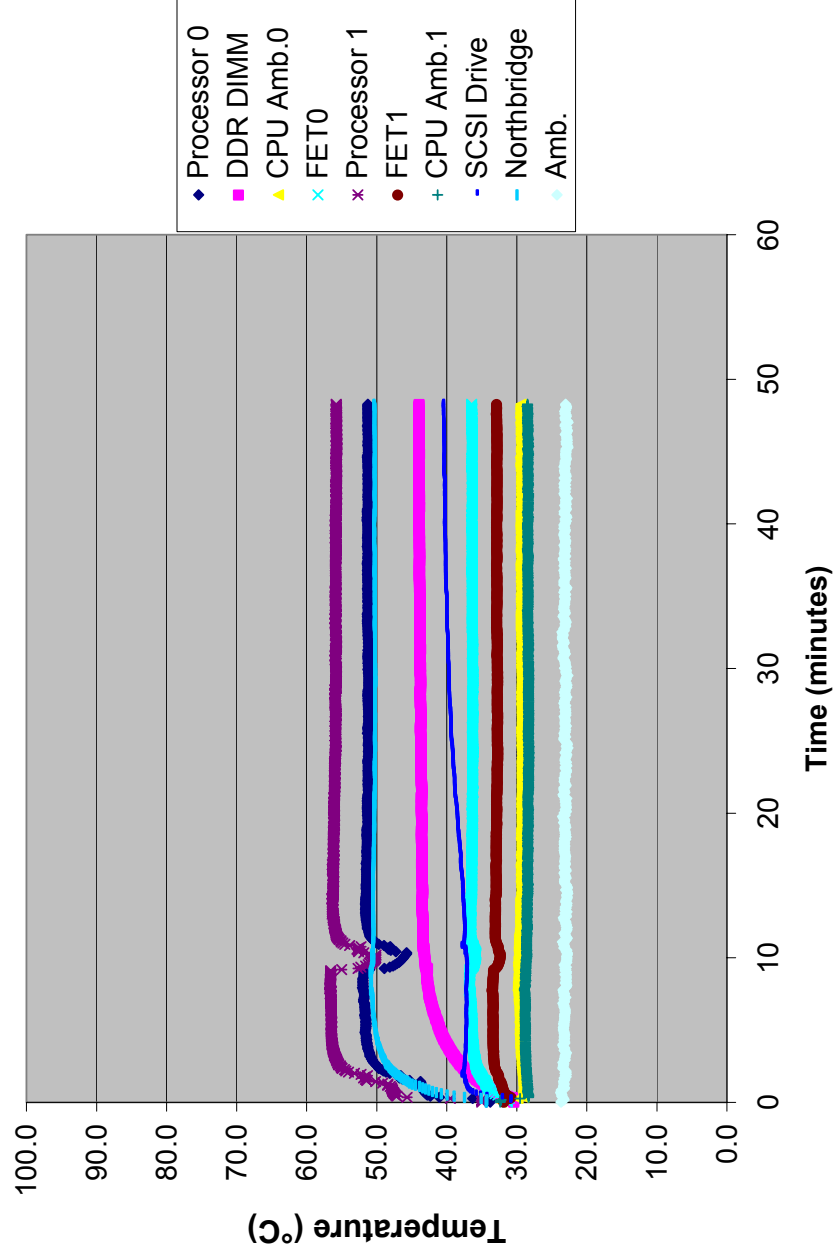


Reference Floor Plan in Lexan Chassis



*Reduced to two blowers in the final configuration.

Temperature Measurements in 1U Floorplan **AMD**



- 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
	6.5	0.595	2000	5.6	0.762	1600
Lexan chassis, dual 800 AMD Athlon™ processors, Taisol 20 Fin 60x60 heatsinks, two NMB blowers, dual 18G SCA drives						

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

Future Development Focus



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- 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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