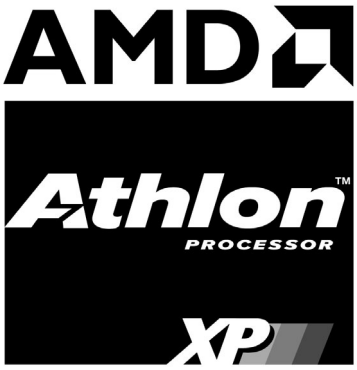
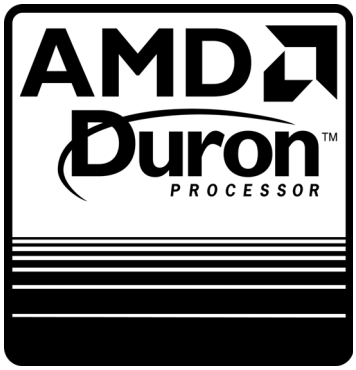
Builders Guide for Desktop/Tower Systems





A concise manual to assist System Builders in assembling desktop/tower systems utilizing the AMD Athlon™ XP and AMD Duron™ Processors

Note: *The product(s) received may vary in appearance from the products illustrated.*

Failure to install the AMD Athlon XP or AMD Duron processor properly may adversely affect operation and may void your warranty coverage.

DO NOT install the processor if it has been damaged.

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Reliable and cost-effective systems are the result of good planning, appropriate hardware components, and consistently good assembly techniques. While this guide can not directly help a system builder with assembly techniques, it is designed to aid in the planning stage, give guidance for many of the hardware choices, and offers techniques for addressing some common problems.

Hardware Considerations

The selection of the proper system hardware is critical to the success of the finished system. For best results, a system builder should *always* contact the supplier or vendor of each component to verify that each of the chosen component supports the desired system configuration. The following is a basic guideline that has been tested and approved by the engineering staff at AMD.

System Enclosure or Case Selection

The choice of the appropriate system enclosure depends on many factors as follows:

1. It must be compatible with the chosen motherboard and power supply.
2. It must be large enough to contain all the devices required.
3. It must be small enough to fit into its intended space.
4. It must be cost effective.
5. It must be reasonably easy to assemble (compared to other choices).
6. It must have good fit and finish, e.g., no razor-sharp edges.
7. It must allow enough airflow through the system to adequately cool all the internal components, especially critical parts like the processor.

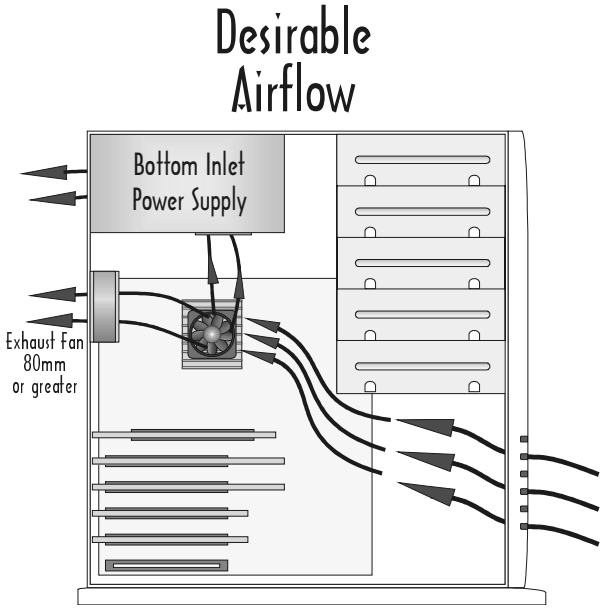
Basic Case Selection Guidelines

The first six factors are relatively self-evident, the seventh one can be elusive. Here are some basic guidelines to aid in finding an enclosure with adequate cooling capability:

- Standard horizontal cases are not recommended—*use vertical cases only.*
- With the vertical case, a power supply with ATX-style bottom air intake vents maintains a better thermal environment than a power supply with only a front air intake vent.
- Cases with an added fan in the back cool better than cases without an added fan.
- The rear fans must all pull air in the same direction; otherwise one fan pulls warm air out of the enclosure while the other fan pulls the preheated air back into the enclosure.
- Front intake fans have not proven to be a significant benefit for vertical cases.
- Fans 80mm or larger work best.
- There must be clear space in front of the system case to allow cooling air to flow in, and space behind the case for the heated air to flow out.
- Cables inside the enclosure can cause airflow disruptions. Cable-tie and route the cables out of the path of the cooling airflow.

Figures 1 and 2 on page 2 show the airflow patterns in a vertical case with either a front-inlet power supply or a bottom-inlet power supply. Testing by the AMD engineers has found the bottom-inlet power supply to be desirable. The figures illustrate why this is.

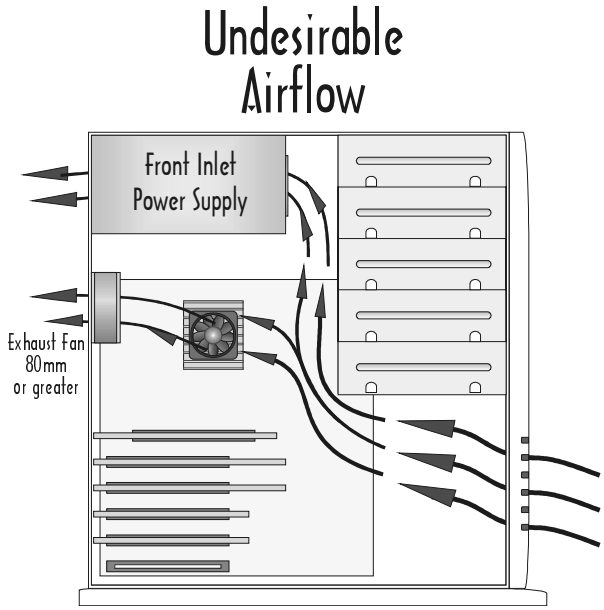
Figure 1 illustrates the desirable configuration.



Testing by the AMD thermal engineers has shown that the airflow pattern in Figure 1 is more desirable than the airflow pattern seen in Figure 2. When the bottom inlet power supply is used, nearly all the air flows near or through the area of the processor. As a result, the processor remains cooler.

Since the heatsinks are heat radiators, like the radiator in your automobile, they need airflow to function properly. The more airflow there is, the better they function.

Figure 1. Desirable Airflow: Power Supply with Bottom Inlet



A power supply with only a front air inlet causes some of the airflow to be diverted directly through the power supply, never passing near the heatsinks. With this type of power supply, there is a greater potential for overheating problems.

Therefore, the AMD thermal engineers do not recommend using power supplies with only a front air inlet configuration.

Figure 2. Undesirable Airflow: Power Supply with Front Inlet Only

Power Supply Considerations

Desktop System Power Supplies

Due to the established infrastructure for AMD processor-based systems and power requirements for the AMD Athlon™ XP and AMD Duron™ processors, AMD no longer tests and recommends power supplies. There is also no official position on the appropriate size of power supply to use. The size used should be based on the power requirements of all the system components (see page 5 for details).

When a system is being built, it is important to be aware that not all configurations will have the same level of power requirements—*some* will require less than what an assembler may consider to be a typical power supply, a few may require more. The size used should be based on the power requirements of the system components. OEMs, system integrators, and end-users should choose a power supply that adequately satisfies the power requirements of the planned system configuration. The section titled ***System Power Consumption*** on page 5 describes how to compute the power requirements for a specific system configuration.

ATX, ATX12V, and OEM Power Supplies

AMD Athlon XP and AMD Duron processor-based systems typically utilize the industry standard ATX/ATX12V power supply specifications. OEMs often use existing ATX/ATX12V power supplies; but should not be limited to that form-factor. Vendors are encouraged to use existing off-the-shelf power supplies when they build their systems.

OEMs, system integrators, and end users should determine power supply requirements based on system configurations and usage. Key items to consider are cost, power requirements, size, mechanical compatibility, and reliability. The system builder must ensure that the power supply meets the motherboard OEM's specifications. Contact the component OEM for further information.

Some of the design rules that standard ATX/ATX12V power supplies should adhere to are:

- Electrical (power distributions, timing requirements, efficiency, output protection, etc.)
- Mechanical (physical dimensions, airflow)
- Electromagnetic compatibility (EMI)
- Reliability and safety

Always ensure that the power supply meets the motherboard OEM's specifications. Contact the motherboard OEM for specific information.

Power Consumption Examples of Output Load Ratings

Table 1 lists the target output ratings for the 300 W ATX-12V power supplies that are often used in AMD Athlon XP and AMD Duron processor-based systems.

Table 1. DC Output Characteristics 300 W

Voltage	Minimum Continuous	Maximum Continuous	Peak
+3.3 V	0.3 A	28.0 A	
+5 V	0.1 A	30.0 A	
+12 V	0.0 A	15.0 A	18 A
– 12 V	0.0 A	0.8 A	
+5 VSB	0.1 A	2.0 A	2.5 A
– 5 V	0.0 A	0.3 A	

Notes:

1. *Maximum continuous total DC output power should not exceed 300 W.*
2. *Maximum continuous combined load on +3.3 V and +5 V outputs should not exceed 80 W.*
3. *Maximum peak total DC output power should not exceed 437 W.*
4. *Peak power and current must be supported for a minimum of 15 seconds.*
5. *Maximum current for the 12 V outputs should be 15 A.*
6. *Peak current for the 12 V outputs should be 18 A.*
7. *The 5 VSB is only utilized when the system is in S3 (Suspend) mode. Therefore, do not add this load to the total load of the power supply.*

System Power Consumption

For reliable operation, the output of the power supply must be greater than the maximum total combined wattage usage for the system configuration. In a standard single-user desktop/tower system, it should be apparent that the maximum wattage usage will be less than the combined total of all the components in the system. The maximum wattage is less because it is almost impossible to concurrently use the maximum power of all the components. Therefore, a power usage factor should be used.

AMD suggests calculating the power supply minimum output capacity as the power required by the processor plus 80 percent of the total wattage for all the other components in a desktop/tower systems. This 80 percent value is not a *hard and fast* value. The system builder's in-house testing may change the power-usage factor.

In addition to the overall wattage requirements, the builder must verify that the maximum voltage for the +5 V and +3.3 V power requirements for the system are less than the wattage limitation on the power supply for the +5 V and +3.3 V outputs.

Processor Power Consumption

The first step is to calculate the power requirements of the processor. For this, you need the power levels at all voltages. Use Table 2 for this purpose.

Table 2. Processor Power Worksheet

Voltage Level and Total Current (V x A = W)			Total Watts for Each Voltage Level
+3.3 V	x	(total amps)	Total Watts for +3.3 V
+5 V	x	(total amps)	Total Watts for +5 V
+12 V (I/O)	x	(total amps)	Total Watts for +12 V (I/O)
+12 V (CPU)	x	(total amps)	Total Watts for +12 V (CPU)
–12 V	x	(total amps)	Total Watts for –12 V
+5 VSB	x	(total amps)	Total Watts for 5 VSB
Total=			Total Combined Wattage=

Notes:

1. *The 5 VSB is only used when the processor is in S3 (Suspend) mode. It is never used while system is being operated.*

2. *To calculate the processor current at 12V VRM source:*

$$I = \left[\frac{(\textbf{Processor Core Voltage} \times \textbf{Processor Core Current})}{\textbf{12}}\right] \times (\textbf{1.25})$$

Where

12 = VRM source voltage and 1.25 is the reciprocal of the 80% voltage regulator efficiency

Calculating System Power Consumption

Use Table 2 on page 5 for the processor power consumption, then enter the values for all of the components into the worksheet in Table 3. Refer to your vendor's documents for power requirements of all added boards and peripherals. List the peak current for each item in the appropriate voltage level column. Then, add the power usage in each column.

Table 3. System Power Worksheet 1

Component	Qty	Maximum Current at Each Voltage Level					
		+3.3V	*+5 V*	*+12 V*	*–12 V*	*5 VSB**	*Power*
Motherboard w/on-board devices							
System fan							
Processor fan							
Memory module							
AGP Video/Graphics card							
PCI modem card							
PCI sound card							
PCI NIC card							
PCI SCSI card							
Other PCI card/Bus card							
PCI RAID card							
IDE hard drive							
SCSI hard drive							
CD-ROM drive							
CD-RW drive							
DVD drive							
Floppy disk drive							
Tape drive							
ZIP drive							
USB devices							
IEEE 1394 devices							
Keyboard							
Mouse							
Other devices (if any)							
Total Current for all devices:						-------	
Processor		--------			--------	-------	
GRAND TOTAL						*	

* The *5 VSB* is only used when the processor is in S3 *(Suspend)* mode. Therefore, it is not included in the power total.

Total Combined Power Used by the System

1. Enter the total current requirements for all the component in the appropriate column.
2. Multiply the voltage by the total current to get the total wattage for each voltage level.
3. Compute the wattage for component power usage, multiply by .8 (to calculate 80% of the wattage for the devices) and add the wattage requirements of the processor. Always verify that your power supply is adequate both overall and for the 3.3V and 5V circuits.

Some Examples of System Configuration Power Requirements

Table 4. Example #1, Power Requirements for a Typical Configuration

Component	Qty	Maximum Current at Each Voltage Level					
		+3.3 V	*+5 V*	*+12 V*	*–12 V*	*5 VSB**	*Power*
Motherboard w/on-board devices	1	3.00	2.00	.30		2.00	23.50
System fan	1			.25			3
Processor fan	1			.25			3
Memory module *(128 MB DDR DIMM)*	1		2				10
AGP Video/Graphics card	1	3.00					9.90
PCI modem card							
PCI sound card							
PCI NIC card							
PCI SCSI card							
Other PCI card/Bus card							
PCI RAID card							
IDE hard drive	1		.8	2.00			28
SCSI hard drive							
CD-ROM drive							
CD-RW drive	1		1.2	.80			15.60
DVD drive							
Floppy disk drive	1		.8				4
Tape drive							
ZIP drive							
USB devices	1		.5				2.50
IEEE 1394 devices							
Keyboard	1		.25				1.25
Mouse	1		.25				1.25
Other devices (if any)							
Total Current for devices:		6.0	7.80	3.60		-------	100.00
Processor (*AMD Athlon™ XP 1800+, 1.533 GHz, 1.75 V*)		------		6.87	--------	-------	82.47
GRAND TOTAL		6.00	7.80	10.47	0.00	*	182.47

* The *5 VSB* is only used when the processor is in S3 *(Suspend)* mode. Therefore, it is not included in the power total.

Note: *In addition to not exceeding the total power (wattage) of the power supply, always verify that the total system requirements of 3.3 V and 5 V power does not exceed the combined 3.3 V and 5 V capacity of your power supply.*

The total of all the components except the processor is 100 watts. Using the formula: *processor power plus 80% of the total of the other components = the power supply size*, this system needs a power supply of at least 162.47 W. Depending on the specific components used, another similar configuration may use more (or less) power. ***Always compute the precise total for the specific configuration planned.***

Table 5. Example #2, Power Worksheet for a *High-Performance* System

Component	Qty	Maximum Current at Each Voltage Level					
		+3.3 V	*+5 V*	*+12 V*	*–12 V*	*5 VSB**	*Power*
Motherboard w/on-board devices	1	3.00	2.00	.30		2.00	23.50
System fan	1			.25			3
Processor fan	1			.25			3
Memory module *(128 MB DDR DIMM)*	3		2				30
AGP Video/Graphics card	1	3.00					9.90
PCI modem card			.50				2.50
PCI sound card		.50	.50				4.15
PCI NIC card		.40	.40				3.32
PCI SCSI card							
Other PCI card/Bus card							
PCI RAID card							
IDE hard drive	2		.8	2.00			56
SCSI hard drive							
CD-ROM drive							
CD-RW drive	1		1.20	.80			15.60
DVD drive	1		1.20	1.10			19.20
Floppy disk drive	1		.8				4
Tape drive							
ZIP drive							
USB devices	2		.50				5.00
IEEE 1394 devices	1		1.60				8.00
Keyboard	1		.25				1.25
Mouse	1		.25				1.25
Other devices (if any)							
Total Current for devices:		6.9	17.30	6.70		-------	189.67
Processor (*AMD Athlon™ XP 2100+, 1.733 GHz, 1.75 V*)		------		7.49	--------	-------	89.91
GRAND TOTAL		6.90	17.30	14.19	0.00	*	279.58

* The *5 VSB* is only used when the processor is in S3 *(Suspend)* mode. Therefore, it is not included in the power total.

Note: *In addition to not exceeding the power supply's total power (wattage), always verify that the total system requirements of 3.3 V and 5 V power does not exceed the combined 3.3 V and 5 V capacity of your power supply.*

The total of all the components except the CPU is nearly 190 watts. Using the formula: *CPU power + 80% of the total of the other components = the minimum power supply size*, this system needs a power supply of at least 241.91 watts. Depending on the specific components used, another similar configuration may use more (or less) power, a significant difference in power needs may exist with seemingly minor variations of the configuration. ***Always compute the precise total for the specific configuration planned.***

Heatsink and Fan Setup Section

Ensure that both the recommended heatsink and thermal interface are properly installed prior to powering up the motherboard. See *How to Install the Heatsink* on pages 10–13 for details.

Special Guidelines

Pay special attention to the following guidelines while installing the processor:

Caution: *The processor may be destroyed if* ***all*** *these guidelines are not followed.*

- Never operate the processor without having an approved heatsink fully and properly attached with the appropriate thermal interface. In order to function, the heatsink must be attached to the socket with the supplied clip.
- Make sure the heatsink used has been tested for the speed rating of the processor used.
- Never run a processor at megahertz speeds greater than the rated megahertz speed.
- Always use an appropriate amount of an AMD-recommended thermal phase-change compound (see Table 6).

  Note: *For production builds, thermal grease is* **never** *an appropriate solution. Thermal grease can be used for short-term testing and validation. When used for a longer period, thermal grease has a tendency to be* pumped out *from the gap between the processor and the heatsink due to the differing thermal expansion and contraction rates of the aluminum heatsink and the processor.*

- *Never* power up the board with the processor heatsink fans unplugged.
- Plug the fans into the fan header connector on the motherboard or power supply as specified by the motherboard manual.
- If the heatsink needs to be removed from the processor, the old phase-change material must be completely removed from the heatsink and processor. Then, new material listed in Table 6 must be installed.

  Note: *Only use a soft plastic scraper to gently remove the old phase-change material from the heatsink and/or the processor.*

- Click on the AMD Athlon XP processor link at www.amd.com for details and listings of available heatsinks.

Table 6 lists the approved thermal interface material. Always check the technical section of the AMD website for any updates to this information.

Table 6. Suggested Thermal Interface Material

Vendor	Material Part # or Name	Material Type
Bergquist	HF225UT	Phase-Change
Chromerics	T725	Phase-Change
Honeywell	PCM45	Phase-Change
Power Devices	Powerfilm	Phase-Change
ShinEtsu	PCS-TC011T-13	Phase-Change
Thermagon	T-pcm905C	Phase-Change

How to Install the Heatsink

Before installing the heatsink, be aware of these very important points:

- Never try to run the processor without a heatsink installed.
- Always make sure there is excellent heatsink-to-processor contact.
- When the system is first running, make sure the fan blades are turning.
- Make certain that nothing is blocking the airflow.

Place the processor into the socket

- To insert the processor, the socket locking arm (see Photo 1) must be raised. To do this, pull it out slightly, then lift up.
- Verify that all four rubber pads are on the processor (see arrows in Photo 2). Contact your supplier if they are not present.
- Gently place the processor into the socket; no force is needed if everything is positioned correctly.
- The cut corner (ceramic PGA) or the corner with the triangle (organic PGA) must be located near the locking arm pivot (see circled area in Photo 2).
- Once the processor is properly placed in the socket, lower the arm and latch it (as shown in Photo 2).
- Do not apply any power (*voltage*) to the system until the heatsink is fully installed.

Caution: ***If voltage is applied before the heatsink is fully and properly installed, the processor* will *overheat and processor failure* will *result!***

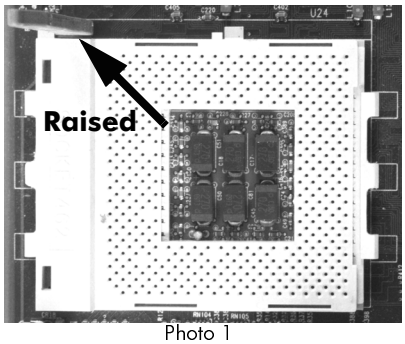


Photo 1

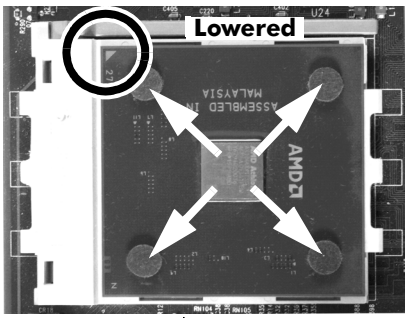


Photo 2

Remove the plastic cover or plastic tape from the bottom of the heatsink

- A portion of the bottom of the heatsink is covered with a rectangle of *phase-change* thermal interface material. This material is protected by either a plastic cover *(like a lid)* over the complete bottom of the heatsink or by a length of plastic tape covering the thermal interface material area. Do not uncover the bottom of the heatsink until you are ready to install it. The thermal interface material must be kept clean to function properly. If the interface material is damaged before the installation is completed, the old interface material *must* be removed and new interface material installed. (Go to the technical area of www.amd.com for details and a list of approved products.)
- If the plastic cover (lid) is present, just pull to remove it (Photo 3).
- If your heatsink has the plastic tape tab, pull quickly at a right angle to the surface of the heatsink to remove only the thin plastic tape and not the soft thermal interface material (Photo 4).

Caution: **Failure to remove the plastic tape film *will* cause overheating and processor failure.**

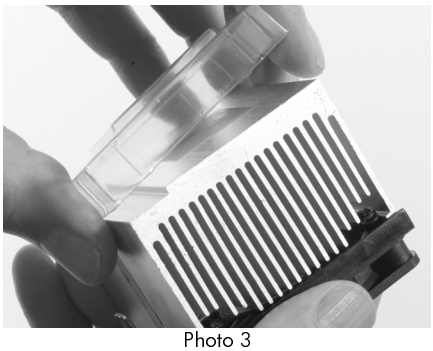


Photo 3

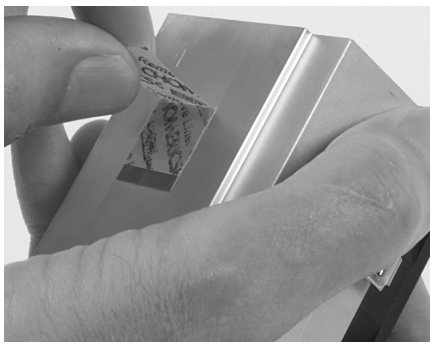


Photo 4

Place the heatsink on the processor, but do not press the heatsink down on the processor (see Photo 5)

Notice that the clip is not symmetrical (top arrow).

Caution: **Verify that the clip pressure point is directly over the die (circled).**

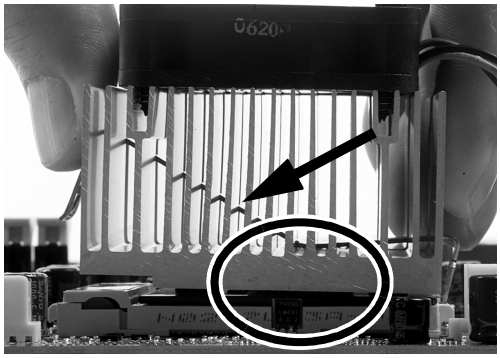


Photo 5

When the heatsink is properly placed, it is sitting only on the rubber pads (Photo 6)

Once the clip is attached, the heatsink is pushed down onto the processor die.

Note: *Your heatsink may vary in appearance from the heatsink illustrated.*

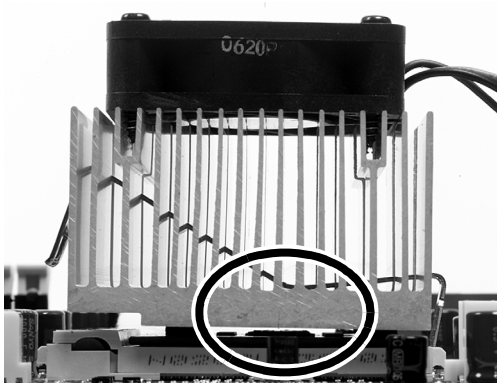


Photo 6

Never allow either of the next two situations to occur:

The heatsink cannot touch any part of the processor socket (see arrow in Photo 7)

If the heatsink does rest on the socket, the processor will overheat and failure will result.

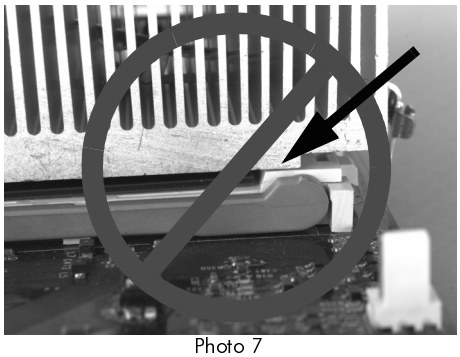


Photo 7

Do not push on the processor die with the heatsink (see Photo 8)

If you do, the die can crack and processor failure will result.

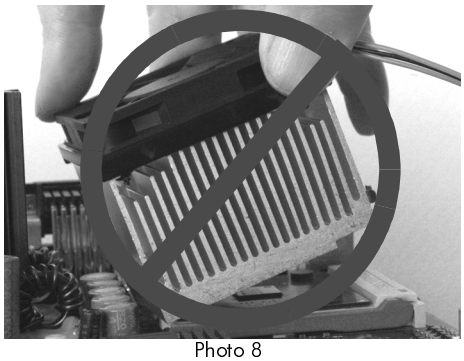


Photo 8

Installing the Retention Clip

Step 1 (Photo 9)

- Make sure the clip is aligned with the plastic socket lug (circled in Photo 9).
- Use the appropriate tool to push ***straight down*** on the heatsink clip.
- Do not apply any pressure to the heatsink itself.

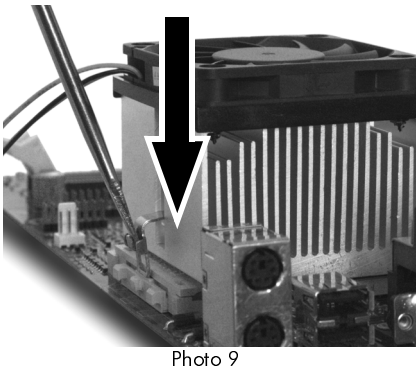


Photo 9

Step 2 (Photo 10)

- Push ***down*** and ***slightly away*** from the socket so the clip moves past the plastic socket lug.

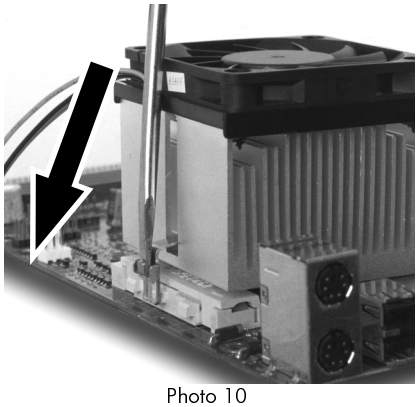


Photo 10

Step 3 (Photo 11)

- Push ***down*** and ***slightly inward*** to secure the clip onto the plastic socket lug.

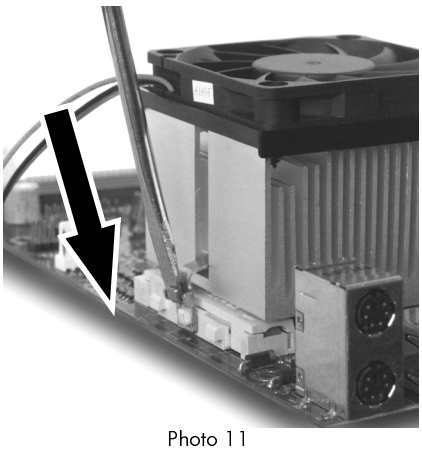


Photo 11

Notes:

1. *It is critical that the retention clip is properly aligned with the plastic socket lug (as circled in* Photo 12*).*
2. *After the heatsink is attached, verify the retention clip is fully seated on the plastic socket lug.*

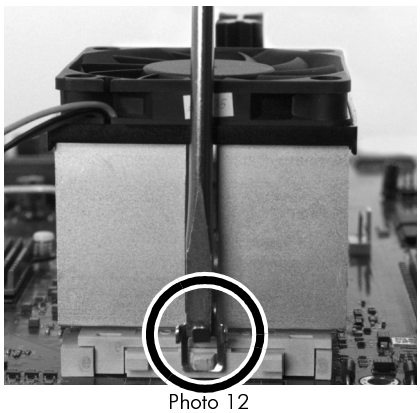


Photo 12

Install the power cable for the heatsink fan

Connect the cable to the appropriate power connector, either to a dedicated socket on the motherboard or to the power connector on the power supply. Check the motherboard manual for the proper installation method (see Photo 13.)

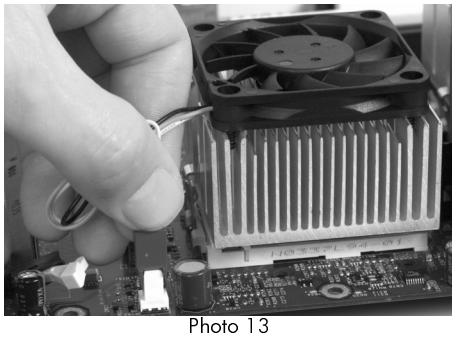


Photo 13

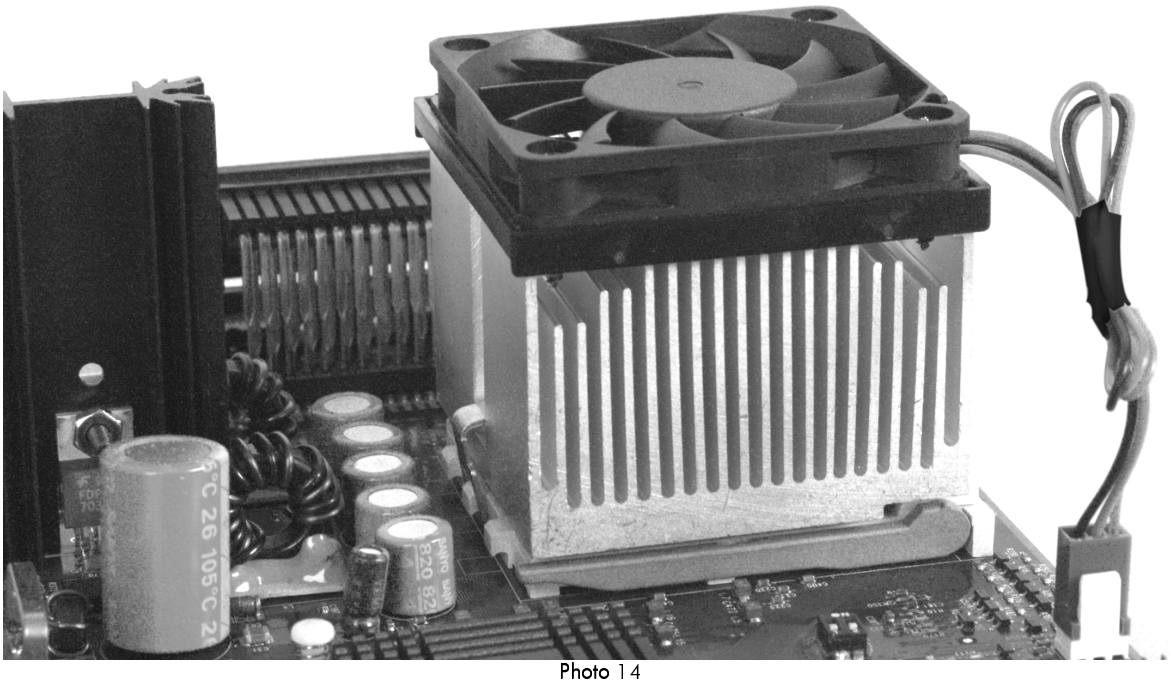


Photo 14

Check the installation completely before starting the system:

1. Make certain that the plastic tape at the bottom of the heatsink has been removed. Also, ensure that the soft thermal interface material has not been removed.
2. Verify that the heatsink is resting squarely on the processor and touching only the processor (the heatsink should never be resting or touching any part of the socket).
3. Check that the long end of the retention clip is attached to the side of the socket with the ledge and that it is securely attached.
4. Double-check that the retention clip is firmly attached to the center lugs on both ends of the socket.
5. Confirm that the heatsink/fan power lead is attached to the proper connector on the motherboard or on the power supply *(check the motherboard manual to verify the proper method)*.
6. When the system is first powered on, verify that the processor heatsink/fan is turning at a rapid rate. If the fan is not turning at a rapid rate, then it is either defective or it is binding.

Note: *If a heatsink is removed for any reason, the old thermal interface material must be completely removed. If removed, new AMD-recommended phase-change thermal interface material must be installed on the heatsink. To remove the old material, a soft scraper must be used. Otherwise, the die may be damaged and processor failure will result. Go to* www.amd.com *if more details are required.*

Memory Guidelines

DDR Memory

AMD has selected an independent testing company, Computer Memory Test Labs (CMTL), to do the compatibility testing for DDR memory. CMTL is an independent test facility and is able to test RAM modules from different module suppliers. System builders should access the CMTL web site at www.cmtlabs.com and view the approved memory module list for the specific motherboard manufacturer and motherboard model. System builders should also verify compatibility of the DDR memory with the memory vendor and/or the motherboard manufacturer.

SDRAM Memory

If the motherboard supports SDRAM memory, the builder must verify with the memory vendor and/or the motherboard manufacturer the compatibility of the intended RAM modules and the specific motherboard.

Type and Number of Memory Modules Supported

The system builder should always verify the type and number of DIMM modules that the motherboard will utilize. Besides considering DDR or SDRAM, be aware that some motherboards can only have a maximum of two memory modules installed if unregistered DIMMs are used. If three (or more) memory modules are required, some systems will require that all DIMMs are registered DIMMs.

Maximum Memory Utilized

The AMD Athlon XP and AMD Duron processors are designed to utilize 4 GB of RAM memory. Many of the system chipsets support this feature. However, not all of the installed memory will be accessible for use by the system OS and the application software.

Note: *With 4 Gbytes of RAM installed, a portion is devoted to system resources. Therefore, less than 4 Gbytes of memory will be available for the operating system and application software.*

Optimal Memory DIMMs Populating Procedure

Always check the motherboard product manual to verify if there is a specific order for the installation of the memory modules. In some systems, DIMM modules must be populated in order, starting with the DIMM1 slot and ending with the DIMM4 slot. DIMM slots 2, 3, or 4 cannot be populated alone. (If the slots are not marked, DIMM1 is the slot closest to the chipset.)

Also, the memory bandwidth on some systems increases as the number of DIMM modules increase. Check with the motherboard vendor or the chipset vendor to verify this.

Starting the System

Power-Up Procedure

Ensure that all the power connectors are plugged in to the motherboard before powering up the board. If the board uses a Voltage Regulator Module (VRM), ensure that the installed processor has its associated VRM installed before starting the system.

Caution: *For boards that use a removable VRM, failure to install the proper VRM before installing the processor and turning on the main power supply can lead to immediate processor failure. If the board has a power regulator built into the motherboard, no special precautions are necessary.*

Drivers and Utilities

Check your local NDA website or the AMD Public website at www.amd.com for the latest versions of the AMD chipset drivers and utilities. Or, you can contact your local AMD field representative.

For all the add-on cards (video graphics, SCSI, etc.), contact the website of the device manufacturer for the latest drivers.

EMI Reduction Techniques

These Electro-Magnetic Interference (EMI) reduction techniques can be implemented with relatively short lead-times at the final system-assembly stage. Proper Electromagnetic Compatibility (EMC) and motherboard design techniques are assumed. For more information on these techniques, please refer to the *AMD Socket A Motherboard Design Guide*, order# 24363 or *AMD Athlon™ Processor EMC Design Application Note*, order# 23828. (These documents are located on the AMD website.)

The effectiveness of all the EMI-reduction techniques varies from system to system. This document helps identify and close the common EMI energy path(s) that allow radiated emissions to escape from the chassis enclosure.

EMI Emissions

EMI emissions from a computer system must be controlled and kept below regulatory limits. Radiated EMI emissions are measured with an antenna, typically ten meters away from the computer system under test. There are different EMI standards for systems marketed in the United States and Europe, and all standards are continually updated. Typically, computers must meet FCC Class "B" requirements to be sold in the United States and meet CE Class "B" EMI requirements to be sold in Europe.

Common System EMI Energy Paths and Solutions

This is a list of common paths for EMI. Each path is followed by a potential solution(s). This list is presented in the best order of evaluation and in relative simplicity to solution implementation.

1. Processor Heat Sink Fan Cable

The large loop to the power connector is a potential problem. Shorten this length as much as possible by routing the cable in a serpentine manner and tying it with a plastic twist-tie. This solution can reduce emissions by 5 dB. Also, shortening the cable path by routing the fan power cable through the heat sink fins (to allow more direct routing) can decrease EMI emissions.

2. Internal Power Cable Routing

The internal power cable can pick up EMI inside the system and can radiate it through the AC power cord. To avoid this, route the internal power cable next to the metal chassis away from the I/O connectors and as far away from the processor heatsink as possible.

3. Other Internal Cable Routing

Cables inside the system should be routed along the metal chassis and away from EMI sources, such as the microprocessor, clock modules, and high-speed VLSI modules. Power cables for drives should be bundled near the power supply, separate from the ATX power cable, and away from the processor heatsink. Always route the front LED cables away from EMI sources, flat to the chassis, and away from the fan openings. Front USB cables must use a shielded internal cable that is grounded to the chassis at the I/O connector. Generally, route all cables cleanly and keep them away from the memory modules. If there are failing signals at 100-, 300-, 500-, or 700-MHz (100/200MHz memory), or 400, 666, or 933 MHz (133/266 MHz memory), the most likely cause is the DIMMs.

4. Rear I/O Connector Shield

The rear plate that touches the rear I/O ports should be made of a metal that has good spring quality, such as stainless steel or spring-hardened steel. Typically, the most vulnerable rear I/O cables are the audio and joystick cables. If EMI emissions drop when these cables are disconnected, then improve the shield-to-chassis grounding for these cables.

5. Motherboard-to-Chassis Ground Too Close to the Processor

Most motherboards have a screw connection between the motherboard ground and the chassis, usually within 20 mm to 40 mm of the processor. EMI tests have shown that in some cases insulating, these motherboard ground-points from the chassis ground can reduce EMI emissions. This solution works because some chassis designs offer lower impedance at high frequency than the material (FR4) that the motherboard is made from.

6. Processor Heatsink Fin Orientation

The fins on the heatsink may create a waveguide that directs the EMI energy toward the fin ends. If the processor heatsink is suspected of causing EMI problems, replacing it with a heatsink with fins running the opposite direction may reduce EMI levels for that system.

7. Processor Heatsink Grounding

In some systems, a ground strap connection to the heatsink can reduce EMI emissions by 4 dB or more. Typically it is better to ground the heat sink to the power supply or to a chassis location close to the power supply.

8. Spread-Spectrum Clocking

Spread-Spectrum (SS) clocking means the clock signal is intentionally varied to spread the timing clock energy over a small frequency range. Go to the BIOS and make sure this is enabled. Always modulate the spread downward so that the processor never runs above its rated speed.

9. Chassis Shielding

Verify that the chassis is sealed tightly at all seams; even a paper-thin gap is a problem. Remember that it is the length, not the width, of a gap or seam in the chassis that compromises EMI shielding. Empty front drive-bays should have multi-contact EMI shielding covers. Sometimes it is still necessary to add finger-stock material to reduce the length of the gaps between the drive and the chassis when the drive bays are populated. Rivets used on the chassis or power-supply case can also be a problem if they are more than five centimeters apart. Too much space between rivets forms a slot antenna. If this condition is suspected, try another brand of power supply with different construction details.

Problem Not Solved

If excessive system level EMI emissions still exist after attempting all of the listed system EMI reduction techniques, then try to determine if the EMI emissions emanate from the system I/O cables (including the AC power cord) or from aperture leaks in the system chassis.

If emissions emanate from a particular I/O cable, then improved filtering or cable shielding may be required on that cable. If EMI emissions emanate from slots or seams in the chassis enclosure, place copper tape across apertures to improve shielding effectiveness. If copper tape reduces emission levels to a satisfactory level, then chassis sheet metal changes or conductive EMI gasketing may be needed at that location.

Checklist for AMD Athlon™ XP and AMD Duron™ Processor-based System Builds

Always make certain the custom system you are about to build uses components from the AMD recommended list or follow the recommendations outlined below to select suitable components. Then, follow this checklist when you assemble the system. For additional configuration information, go to: www1.amd.com/athlon/config or www1.amd.com/duron/config.

- ❑ 1. Ensure the selected motherboard is appropriate for the chosen processor model and frequency. Check the AMD Athlon™ XP or AMD Duron™ processor *Recommended Motherboards* list at www.amd.com.
- ❑ 2. Verify that your case follows the system case (chassis) airflow guidelines on the AMD website.
- ❑ 3. Check that the capacity of the power supply is adequate. The individual voltage capacities must be sufficient for the system power draw. Always calculate the required power supply capacity (see page 5 of this document) or attempt to verify compatibility from the power supply manufacturer. An inadequate power supply will cause a system to be unreliable.
  Note: *Your case design may require the power supply to be installed before any of the other components.*
- ❑ 4. Wear a grounding strap, and ensure that you are properly grounded at all times during the system construction, to protect the delicate electronic components from static electricity damage.
- ❑ 5. Install the selected hard drive(s), floppy, DVD or CD-ROM player, and other devices into the chassis.
  Note: *Check the hard drive installation guide. For full performance, you MUST also install the appropriate data cable as listed in the hard drive manufacturer's drive installation instructions.*
- ❑ 6. Remove the motherboard from its protective packaging and place it on a firm (but not hard) surface. A grounded anti-static pad is the ideal surface.
- ❑ 7. Remove the processor from its protective packaging (make sure you are electrically grounded), install the processor into the motherboard socket, then install only an AMD-recommended heatsink and fan assembly. Use the provided phase-change thermal material, never use thermal grease. For specific information, follow the instructions found in the *Processor Installation Guide* on the AMD website.
- ❑ 8. Install the standoffs needed to support the motherboard in the case/chassis, especially where the cards will be placed. Install the assembled motherboard with processor and heatsink into the cases.
- ❑ 9. Check the motherboard for any jumper settings. (Most motherboards do not require jumpers.)
- ❑ 10. Ensure the selected memory is shown on the motherboard maker's recommended memory list (a minimum of 128 Mbytes is recommended). If the motherboard manufacturer does not have a verified/recommended memory listing, check to see that the memory supplier has tested your chosen motherboard and deemed it to be compatible with the RAM memory modules you plan to use.
- ❑ 11. Install the recommended memory into the motherboard. On some motherboards, a specific sequence is used to install the memory modules. Always install the RAM in the sequence required. Verify that each memory DIMM is inserted all the way into the socket and locked in place.
- ❑ 12. If there is an AGP slot, install your high-performance AGP video/graphics card. Have the latest drivers available (see the website of the card maker). You will need the drivers shortly.
- ❑ 13. Connect the power cables to the drives and motherboard.
- ❑ 14. Connect the hard drive, floppy, and DVD (CD-ROM) data cables in the normal manner. Verify that the cables are installed securely and the colored edge is by ***Pin 1*** on both the drives and the motherboard.
- ❑ 15. Connect the monitor data cable, keyboard cable, and mouse cable to the rear of the system.
- ❑ 16. Install the AC line power cord on the power supply and connect it to the power outlet.
- ❑ 17. Go to the websites of the motherboard vendor or the chipset maker. Check the vendor's web site for the latest version of the BIOS, AGP miniport driver, and bus mastering IDE driver. (AMD has drivers available for its chipsets. See www.amd.com.)
- ❑ 18. Check the peripheral manufacturer's web site for the latest drivers for the sound card, network interface card, the video graphics card, and any other added devices.
- ❑ 19. Power the system on and begin loading just the minimum software, the OS, and any required drivers.
- ❑ 20. Make sure the system starts and runs reliably with just the graphics card installed. Restart and run the system multiple times. Try to find potential problems early since there are fewer components to check.
- ❑ 21. If other cards are to be installed, install them now—one at a time. Turn off the system and unplug it before installing each card. Restart the system after every card installation.
  Note: *If you have difficulties with the installation of any of the cards or drivers, read the AMD technical document entitled* Complex Configurations and IRQ Info*, available on the AMD website.*
- ❑ 22. As you install each card, verify the card is properly installed (connector is fully inserted into the slot, check the front and back) and that the retention screws are in place.