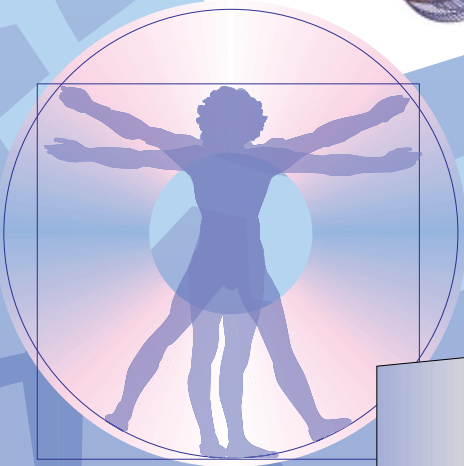
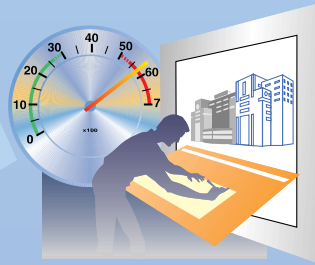
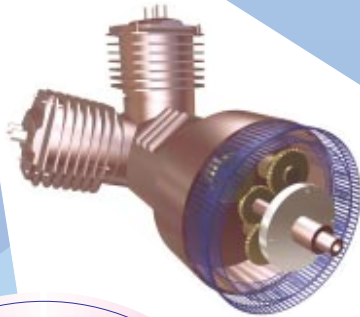
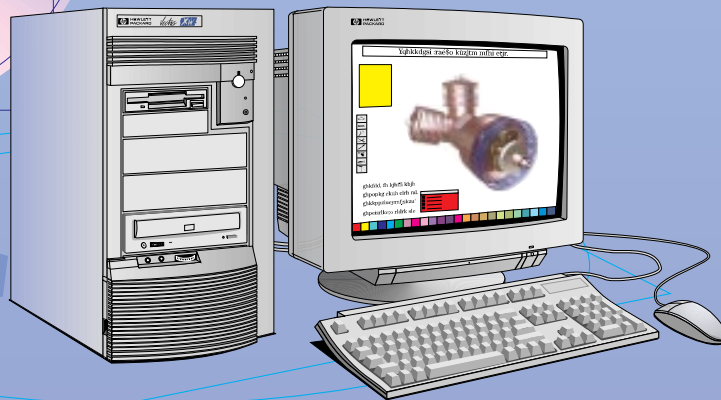

Guide to Optimizing Performance



HP Vectra XU



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The Performance Benefits of Your HP Vectra PC

Your Hewlett-Packard PC makes use of a number of new features to provide you with the best performance currently available from a PC. The configuration of your PC has been optimized by HP to make the best use of these features for general applications.

The performance of your PC will depend on the applications you use. For example, different software applications require different amounts of memory and will produce files of different sizes. Best performance is obtained by balancing your PC's configuration with the requirements of your software.

To provide versatility in your PC's configuration, Hewlett-Packard offers a number of performance-enhancing accessories. Some of these are upgrades that allow you to increase the performance of your PC in one particular area. Other accessories add to your PC's existing capabilities.

This guide describes the high-performance features of your PC and how you can obtain maximum benefit from them. This will help you to optimize the performance of your HP Vectra PC for your specific use.

This guide is presented in two chapters:

- Your PC's performance features
Describes the new features used by your PC, with suggestions on how to optimize their performance.
- Technical reference
Gives general technical reference information, with emphasis on the new features used by the HP Vectra XU PC.

NOTE

The advanced Pentium™ Pro processor installed in your PC provides the best performance when used with 32-bit operating systems and applications.

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Your PC's Performance Features

This chapter describes the new features of your HP Vectra XU PC and how these features can bring optimized performance to your desktop application.

Overview

Your HP Vectra XU PC provides a number of new features that bring unprecedented levels of performance to your desktop application. Some of these features offer you their full performance benefits immediately, without needing to be adjusted in any way. Other features must be configured according to your use before their full benefit can be realized.

This chapter explains these new features so that you can better understand the performance benefits they offer. Where a feature is configurable or can be upgraded, detailed descriptions are given to help you understand the options available to you.

The following features of your PC are described in this chapter:

- Intel Pentium™ Pro processor
- Dual processing capability
- Flexible memory configuration
- Advanced operating system support
- PCI (Peripheral Component Interconnect) bus
- Support for Ultra SCSI devices
- High performance IDE (Integrated Drive Electronics) mass storage
- Advanced graphics capabilities
- High quality, stereo audio recording and playback
- Fast and adaptable networking.

Your PC's Configuration

The configuration of your PC has been optimized by HP for general use. However, the performance of your PC can be further improved by changing this configuration to match the requirements of your application.

You can change the configuration of your PC in three ways:

- Adjust the parameters of the existing configuration through the PC's Setup program
- Install accessories
- Change the configuration parameters of your software to make the best use of your PC's features.

NOTE

The advanced Pentium Pro processor installed in your PC provides the best performance when used with 32-bit operating systems and applications.

Performance Topics

The following topics are covered in this chapter:

- Improving the performance of your PC's processor
- Advantages of dual processor configurations
- Matching memory capacity to your requirements
- Benefits of 32-bit applications
- Installing fast peripherals on the PCI bus
- Increasing the speed limit with Ultra SCSI
- Making the most of your IDE channels
- More video performance
- Your PC's audio resources
- HP PCI integrated 10/100BT LAN interface
- HP PCI integrated 10/100VG LAN interface.

1 Your PC's Performance Features

Improving the Performance of Your PC's Processor

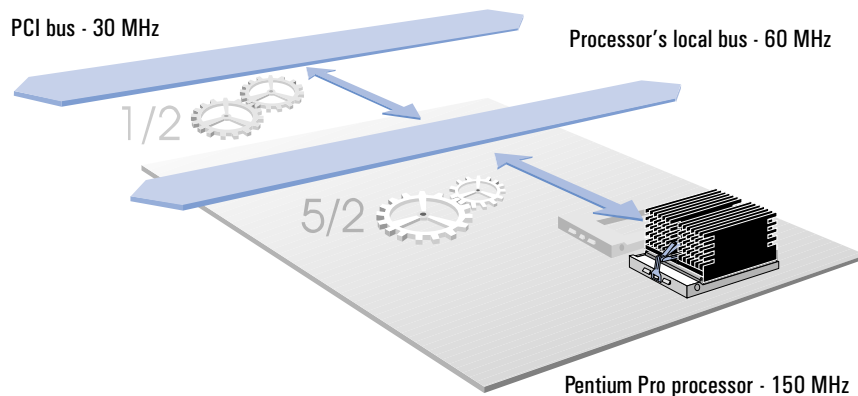
Improving the Performance of Your PC's Processor

Your HP Vectra XU PC uses the most powerful processor currently available in any HP Vectra PC: the Intel Pentium Pro. The advanced capabilities of this processor are sufficient to handle any desktop application you may use. However, it is also possible to further increase the performance of your PC's processor by replacing it with an upgrade processor. This section explains how and why.

The Processor's Clocks Everything your PC's processor does is synchronized to a regular pulse known as the processor clock. The speed of this clock defines the speed at which your processor performs its work.

Your PC's Pentium Pro processor uses a system board clock source of either 60 or 66 MHz. All operations on the local bus (such as data transfers with memory) are synchronized to this clock. Other devices in the PC also use this clock to generate their own clock signals; for example, the Peripheral Component Interconnect (PCI) bus controller divides this clock in half to produce the 30 or 33 MHz PCI clock.

For its own internal operation, the Pentium Pro processor multiplies the clock source to obtain a faster, internal clock. It is the frequency of this internal clock that defines your processor's speed. For example, the 150 MHz processor uses the 60 MHz clock source and multiplies this by $5/2$ to produce its own 150 MHz internal clock.



NOTE

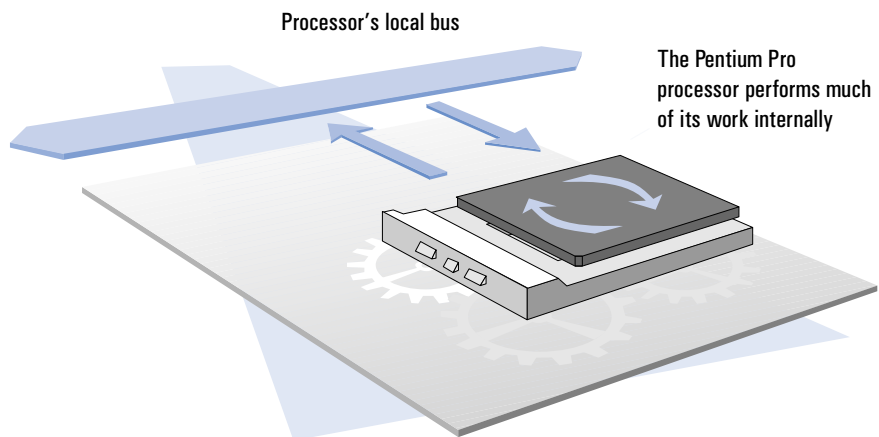
The advanced Pentium Pro processor installed in your PC provides the best performance when used with 32-bit operating systems and applications.

Inside the Processor

Internally, your PC's processor performs tasks by breaking them down into sub-tasks. Each of these sub-tasks requires a number of clock cycles to complete.

The Pentium Pro processor integrates some functions that were performed by external components in previous generations of PCs; level-two cache memory is an example of one of these functions. This means that the Pentium Pro processor can perform a significant proportion of its work internally, without needing to access other PC components through the local bus.

By using a faster clock for internal operations than for external (local bus) operations, the Pentium Pro processor accelerates the work it performs internally. Since internal operations represent much of the processor's total activity, the effect of this acceleration is a significant improvement in overall processor performance.



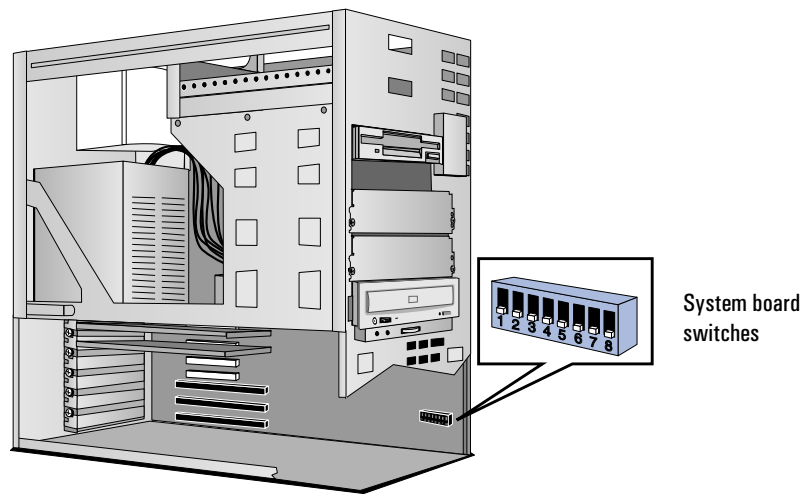
1 Your PC's Performance Features

Improving the Performance of Your PC's Processor

The Scope for Improvement

The multiplication factor that the processor applies to the (external) clock source to produce its internal clock can be compared to the transmission in a car; increasing the transmission ratio allows the car to go at higher speeds. Similarly, increasing the multiplication factor that the processor applies to the clock source causes the processor to use a faster internal clock, and so to operate more quickly.

The processor's clock multiplication factor is determined by switches on your PC's system board. These switches set both the internal and external clock speeds for the processor and must be set correctly for the speed of processor installed in your PC.



| Switch 4 | Switch 6 | Switch 7 | Processor Speed (Internal Clock) | Local Bus Speed (External clock) | Clock Multiplication Factor |
|----------|----------|----------|----------------------------------|----------------------------------|-----------------------------|
| ON | ON | OFF | 150 MHz | 60 MHz | 5/2 |
| OFF | ON | OFF | 166 MHz | 66 MHz | 5/2 |
| ON | OFF | ON | 180 MHz | 60 MHz | 3 |
| OFF | OFF | ON | 200 MHz | 66 MHz | 3 |

Advantages of Dual Processor Configurations

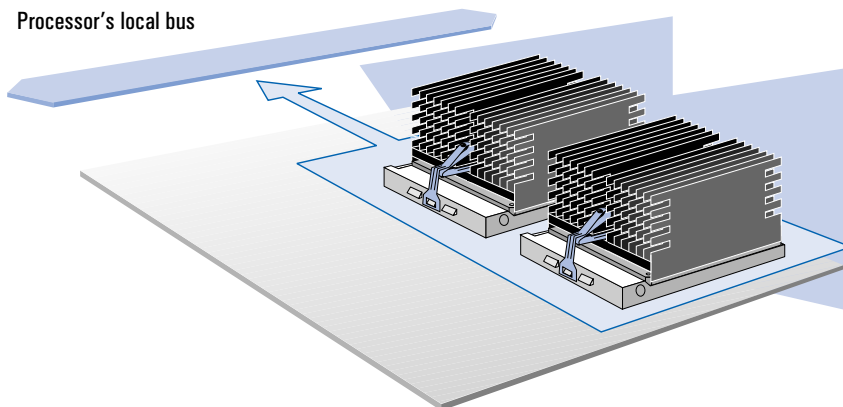
Although the Pentium Pro processor in your PC is the most powerful processor currently used by any HP Vectra PC, one HP Vectra is able to offer an even higher processing performance: your HP Vectra XU! This is possible because your PC can use not one, but two of these advanced processors when running certain operating systems.

Two Processors Can Be Better Than One

The Pentium Pro processor in your PC is installed in a socket for easy upgrading. Your PC's System board also provides another socket, for installation of a second Pentium Pro processor.

Your HP Vectra XU PC is fully compliant with the Intel Multiprocessor Specification (MPS) for dual processing in PCs. This standard defines how multiple processors work with a single set of system memory and I/O resources.

The HP Vectra XU supports symmetric multiprocessing, which means that each processor can perform any task. Symmetric multiprocessors appear to the user as a single, more powerful processor.



1 Your PC's Performance Features

Advantages of Dual Processor Configurations

If your PC is running an MPS-ready operating system, installing a second Pentium Pro processor will yield a significant performance advantage. The second processor works alongside the first and shares the processing workload. This can increase the overall processing performance of your PC by up to 80%, depending on your application.

NOTE

The advanced Pentium Pro processor installed in your PC provides the best performance when used with 32-bit operating systems and applications.

When is a Second Processor Used?

To be able to make use of a second processor, your PC must be running an MPS-ready operating system, such as Windows NT or SCO UNIX. If your PC is not running an MPS-ready operating system, you will not be able to gain any benefit from installation of a second processor.

The table below shows which of the more commonly used PC operating systems are MPS-ready.

| Operating System | 32-bit? | Multithreaded? | MPS-Ready? |
|------------------------|---------|----------------|------------|
| MS-DOS | No | No | No |
| Windows for Workgroups | No | No | No |
| Windows 95 | Yes | Yes | No |
| Windows NT | Yes | Yes | Yes |
| SCO UNIX | Yes | Yes | Yes |
| Solaris | Yes | Yes | Yes |
| NEXTSTEP | Yes | Yes | No |
| OS/2 Warp 3.0 | Yes | Yes | No |

Refer to the manual supplied with your operating system for more information on its characteristics and capabilities.

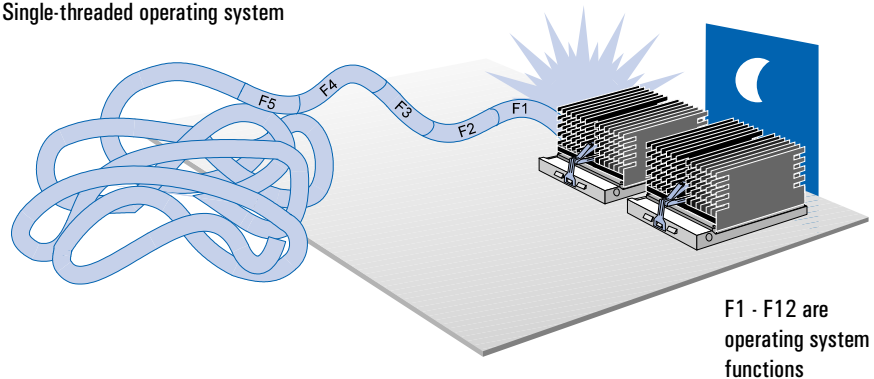
Multithreaded
Operating Systems

Any operating system consists of a number of functions, each of which controls some small part of the PC's operation. Application software uses these functions as building blocks to create specific, more powerful tools for the user.

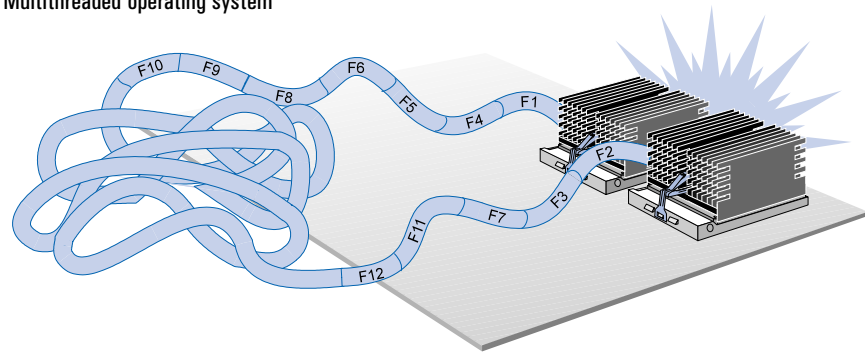
Under a single threaded operating system no individual function is independent. All operating system work (including any work performed by an application) consists of a single, inseparable thread of functions and so must be performed by the same processor.

A multithreaded operating system uses functions that are effectively independent. This allows the operating system to break its work into separate threads of functions. Since the threads are effectively independent, they can be followed by different processors.

Single-threaded operating system



Multithreaded operating system



1 Your PC's Performance Features

Advantages of Dual Processor Configurations

MPS-Ready Operating Systems

An MPS-ready operating system is multithreaded and also guarantees the integrity of any data shared between the different processors. Data integrity is essential in any environment where multiple copies of the same data can exist — failure to guarantee this can lead to logical conflicts and operational failure. MPS-ready operating systems protect against these risks by ensuring that valid copies of the same data are identical.

Multiprocessor- Efficient Operating Systems

Some advanced operating systems are more than MPS-ready. They are also multiprocessor-efficient. These operating systems gain maximum advantage from multiple processors. Windows NT is an example of a multiprocessor-efficient operating system.

Multiprocessor-efficient operating systems reduce the length of the individual functions contained within their different threads. In an MPS-compliant multiprocessing computer, all processors share the same local bus and must load the functions they perform over this bus. By reducing the length of these functions, a multiprocessor-efficient operating system ensures that no processor is slowed while another processor loads a function over the local bus. This guarantees that each processor is used to its best advantage.

Multithreaded Applications

Applications written specifically for multithreaded operating systems are also multithreaded. These applications permit their own operation to be performed through separate threads. Refer to the manual supplied with your software application to determine if it is multithreaded.

The Advantages of Dual Processing in your PC

Your HP Vectra PC is able to bring the advantages of multiprocessing to your desktop. With two processor's installed, the power of your PC is significantly increased. However, this does not mean that your PC can process individual commands and instructions more quickly. Instead, your processing capacity is increased, meaning that your PC can process more commands and instructions at one time.

The use you make of the second processor will be determined by the applications you use. To illustrate this, assume you are running a multithreaded operating system with the following applications:

- One single-threaded application.
Both processors are able to share the operating system's work, but all the work for the application must still be carried out by a single processor. The performance of your PC may be faster than if you had only one processor installed, but not by a significant factor.
- Two or more single-threaded applications simultaneously.
Each processor will perform the work for different applications. The performance of your PC will be significantly improved by the second processor.
- A multithreaded application.
Both processors are able to share the work of the application. All work is shared and so the performance will be significantly increased with respect to a single processor configuration. Multithreaded applications will gain the maximum benefit from installation of a second Pentium Pro processor in your PC.

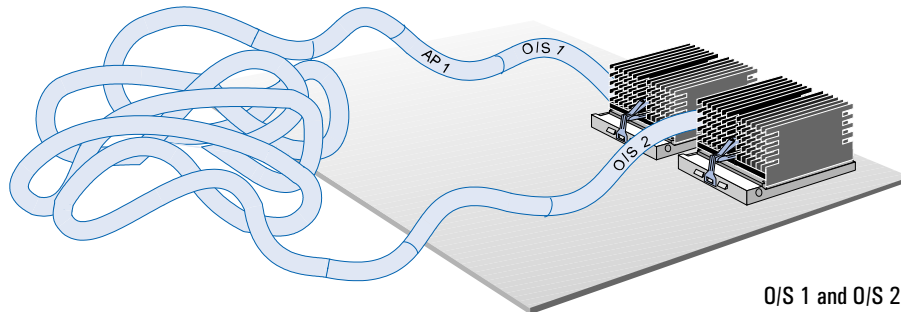
NOTE

The advanced Pentium Pro processor provides the best performance when used with 32-bit operating systems and applications.

1 Your PC's Performance Features

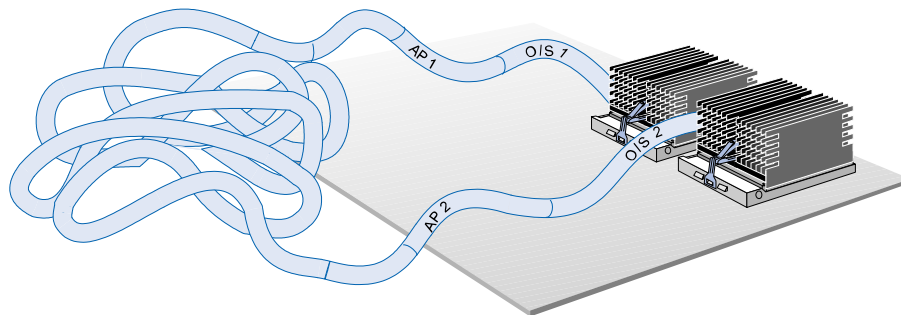
Advantages of Dual Processor Configurations

One single-threaded application



O/S 1 and O/S 2
are multithreaded
operating system
functions

Multiple single-threaded applications or one multithreaded application



AP 1 and AP 2
are application
functions

This distinction is important. If you are running a multithreaded operating system, and use multithreaded applications or multiple single-threaded applications, installing a second Pentium Pro processor will significantly improve the performance of your PC. If, however, you run just one single-threaded application, then installing a second processor will offer little, or no performance advantage.

The following table summarizes the benefits of installing a second Pentium Pro processor according to the operating system and applications you use.

| | Multiple applications | One multithreaded application |
|----------------------------------|---|---------------------------------------|
| Single-threaded operating system | None | None |
| Multithreaded operating system | Performance improvement for all applications (even single-threaded) | Greatest benefit from multiprocessing |

Other Benefits of Dual Processing

One of the most important functions that a processor performs is handling interrupts. An interrupt is a request for attention or service from another area of the PC. The processor's ability to respond to interrupts is an essential part of your PC's operation. Interrupts allow your PC to respond to unexpected events.

To handle an interrupt, your processor must first suspend its current activity. This means that your PC's operation will be slowed temporarily while the interrupt is being handled.

With two Pentium Pro processors installed the responsibility of handling interrupts is shared between them. When an interrupt request is received, the two processors arbitrate between themselves to see which processor is performing the lowest priority work. The selected processor will be allocated to handle the interrupt, leaving the other processor free to continue with its work.

1 Your PC's Performance Features

Advantages of Dual Processor Configurations

Additional Advantages of Dual Processing with your HP Vectra PC HP has proven experience in the successful design of dual processing PCs. Previous HP Vectra PCs have used the Pentium processor to bring MPS-compliant multiprocessing to desktop applications.

Compared with the previous generation Pentium processor, the Pentium Pro offers an additional performance advantage when used in dual processing configurations: an integrated 256 KB level-two cache memory.

Cache memory increases the performance of any processor by making copies of the most frequently used data and instructions available more quickly. The Pentium and Pentium Pro processors also provide integrated, level-one cache memories of smaller capacity.

With the Pentium processor, level-two cache memory was external to the processor. This meant that accesses to this memory were performed over the local bus. In dual processing configurations, this memory was shared between the two processors.

The Pentium Pro integrates level-two cache memory into the same package as the processor and is able to access this memory without using the local bus. This feature leads to these additional performance advantages when the Pentium Pro processor is used in dual processing configurations:

- Because the level-two cache memory is integrated inside the processor, it can be accessed at the speed of the processor's internal clock and not at the speed of the slower, local bus clock.
- Accesses to the level-two cache memory do not cause accesses over the local bus and thus do not risk slowing the operation of the other processor.
- Since each Pentium Pro processor integrates a level-two cache memory, dual processing configurations provide two level-two cache memories. This doubles the overall capacity of level-two cache memory in your PC.

Limitations

If two Pentium Pro processors are installed, they will operate at the same clock speeds.

Matching Memory Capacity to Your Requirements

The memory supplied with your HP Vectra XU PC is sufficient to run any standard PC operating system. However, for certain applications, the performance of your PC will be improved by installing additional memory.

Your PC's Memory Capacity

The memory capacity of your PC has a very important influence on overall performance. Memory is your processor's workspace. If this workspace is too small, the processor's work will be slowed and this will affect the overall performance of your PC.

Your HP Vectra PC has four banks for installing main memory. Memory can be upgraded through installation of additional memory modules. Memory modules must be installed in pairs and can be ordered from HP in the following capacities:

- 32 MB (two 16 MB modules)
- 64 MB (two 32 MB modules)
- 128 MB (two 64 MB modules).

The maximum memory capacity of your PC is 512 MB. Refer to your PC's *User's Guide* for more information on installing memory.

The memory modules used by your PC are 72-bits wide, comprising 64 bits of data and 8 bits of Error Correcting Code (ECC) data for increased data integrity. The ECC code is generated each time data is written to the memory and checked when the data is read from memory. The ECC code enables automatic correction of any single-bit data error that occurs.

1 Your PC's Performance Features

Matching Memory Capacity to Your Requirements

Do You Have Enough Memory?

The ideal memory capacity for your PC is determined by the operating system and applications you use. If you frequently use multiple applications at one time, you will need more memory than if you use only single applications.

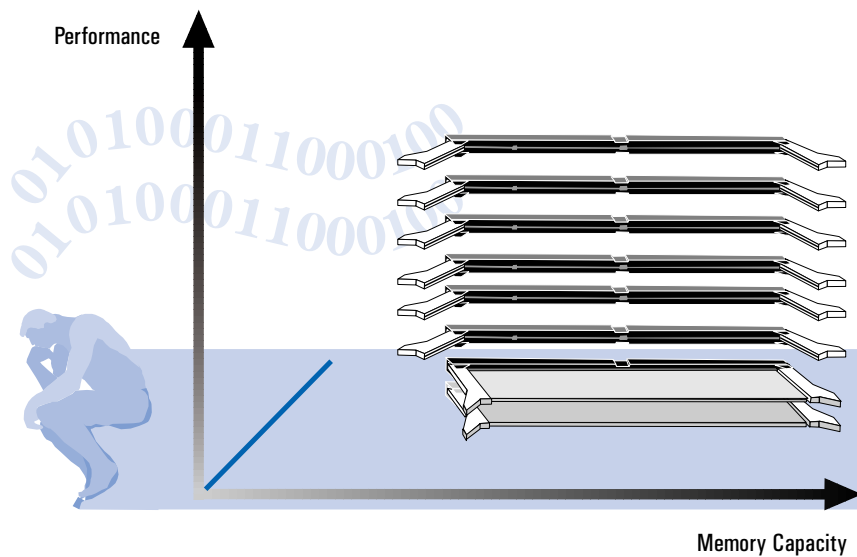
Typical memory requirements for some operating systems are shown in the following table. These are based on the general requirement of the operating system running a typical application. If you use memory-hungry applications (for instance, a computer-aided design program), or frequently run multiple applications, your PC will require more memory than indicated below.

| Operating System | Minimum Configuration | Recommended Configuration |
|------------------------|-----------------------|---------------------------|
| Windows for Workgroups | 4 MB - 8 MB | 12 MB - 16 MB |
| Windows NT | 12 MB | 24 MB - 32 MB |
| Windows 95 | 8 MB | 16 MB - 24 MB |
| OS/2 Warp | 4 MB - 8 MB | 16 MB |

There is no general formula for deciding how much memory you should install in your PC. Your need for memory is determined by the operating system you install and by the applications you want to use.

If You Do Not Have
Enough Memory

If you do not have sufficient memory for the applications you are running, your PC will compensate by using hard disk space as virtual memory. Since your processor is able to access memory approximately 200 times faster than it can access a hard disk, the negative effect on performance is significant.



Windows NT

If you are using Windows NT, you can use the Performance Monitor utility to monitor your use of memory and other system resources. Among other indications, the Performance Monitor will report any use you are making of the Windows NT swap file.

The swap file is the virtual memory on your hard disk used by the processor when insufficient memory is available. If the Performance Monitor indicates that your PC is making use of the swap file, then the performance of you PC will be improved by adding extra memory.

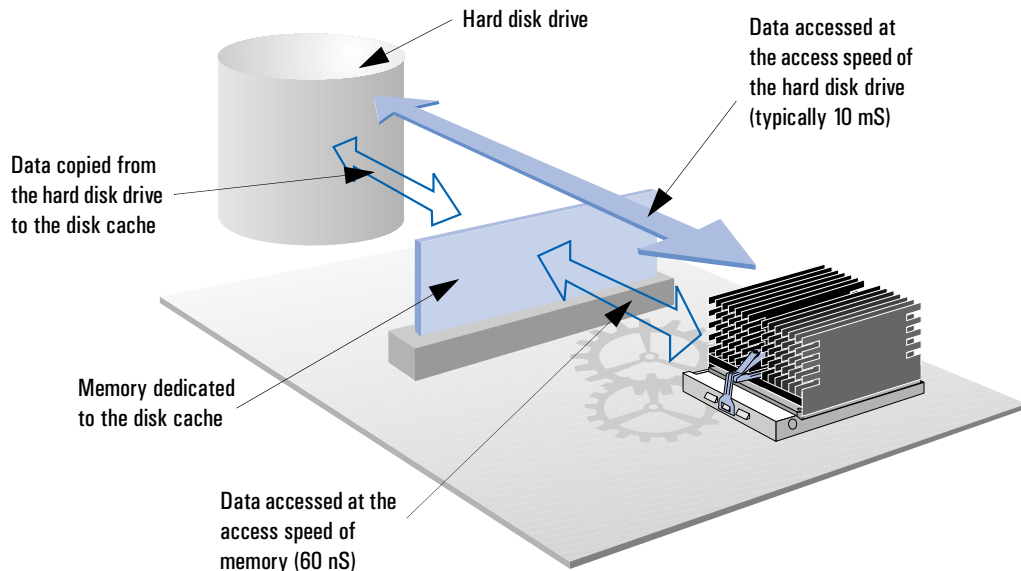
1 Your PC's Performance Features

Matching Memory Capacity to Your Requirements

What Else is Memory Used For?

Many operating systems use memory to accelerate data transfers with the PC's hard disks. To do this, an area of memory is dedicated to a disk cache, which stores copies of the latest data read from or written to the hard disks. If the processor then accesses the same data again, it will be loaded from memory at much higher speed than from hard disk.

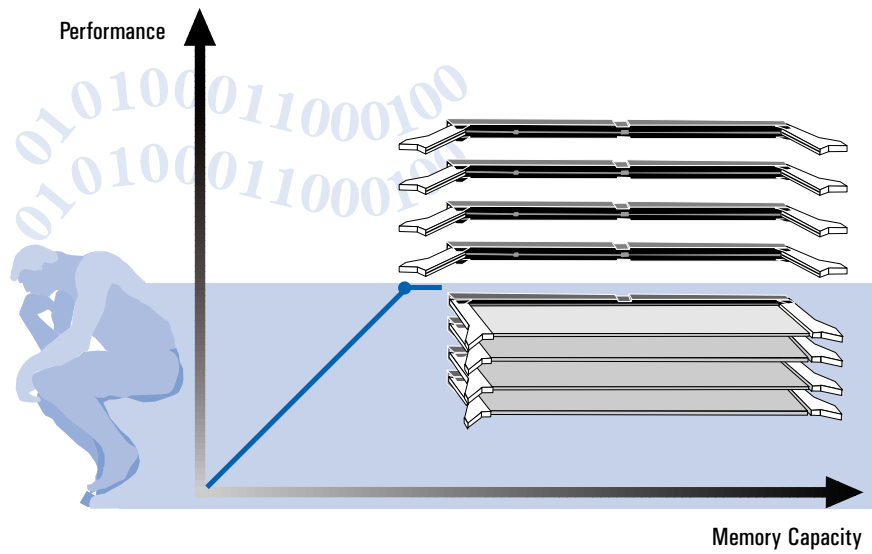
Because much of your PC's work is repetitive, disk caches offer a significant performance advantage with most applications. The amount of memory dedicated to the disk cache is determined by the operating system you are using.



Some operating systems, such as Windows for Workgroups, allocate a fixed disk cache, which you can configure directly. Others, such as Windows NT and Windows 95, use a dynamic allocation mechanism that configures the disk cache according to the amount of memory available.

The memory used by the disk cache will not be available for use by your applications. When determining your memory requirement, remember to add an extra allowance for the disk cache.

Installing More Memory If your PC has less memory installed than your operating system and applications require, then installing more memory will significantly improve your PC's performance.

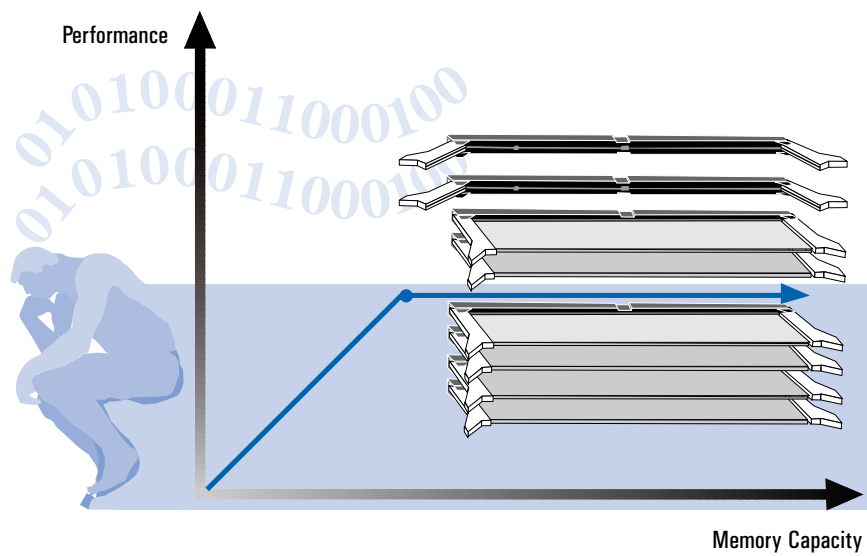


1 Your PC's Performance Features

Matching Memory Capacity to Your Requirements

Does Installing More
Memory Always
Improve Performance?

Once you have sufficient memory, any extra memory you install will have no effect on performance. Indeed, surplus memory will probably not be used.



Benefits of 32-bit Applications

Your HP Vectra PC has been designed to offer optimized performance. The benefit that you can gain from your PC's advanced features will be determined by the software that you use.

NOTE

The advanced Pentium Pro processor installed in your PC provides the best performance when used with 32-bit operating systems and applications.

Applications and the Processor

Any application you run on your PC presents itself to you as a single unified object. But to the processor an application consists of many single instructions, each of which controls some small part of the overall function of the application.

Each instruction is applied to source data from memory to produce new (result) data. When executing an instruction, the processor loads the source data and its associated memory address (location) into a temporary storage area called a register. The new data produced and its corresponding address are also stored in registers.

32-bit Applications

For 32-bit applications all of these quantities are 32-bits in length; the instructions are 32-bits long and act on 32-bit data items which have corresponding 32-bit memory addresses.

16-bit Applications

Many of today's more popular applications, including any designed for Windows for Workgroups, are 16-bit applications. These use 16-bit instructions, and handle both data and memory addresses as 16-bit quantities.

1 Your PC's Performance Features

Benefits of 32-bit Applications

The Pentium Pro Processor

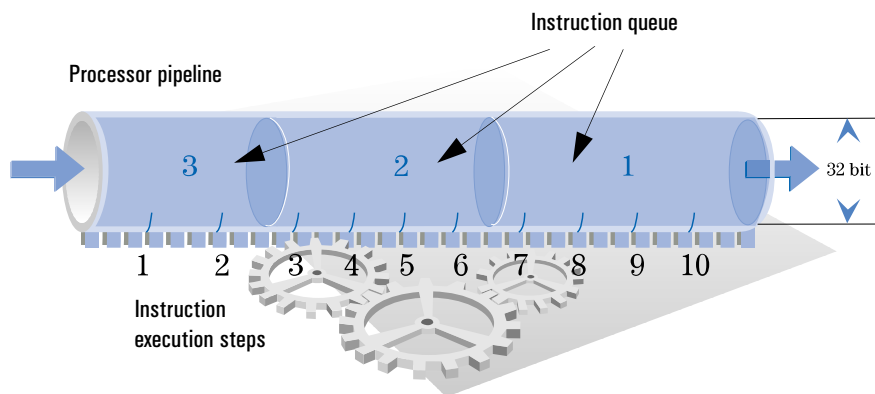
The Pentium Pro processor in your PC is a 32-bit processor. This means that it has been specifically designed to execute 32-bit instructions, and has 32-bit registers for storing data and addresses. Your PC will give optimized performance when running 32-bit applications.

If you run 16-bit applications, you may be disappointed with the performance of your PC. This is because 16-bit applications are unable to use many of the Pentium Pro processor's performance-enhancing features.

Using Pipelines to Accelerate Instruction Execution

The processor executes instructions in a number of steps through a sequential process called a pipeline. The Pentium Pro processor has three pipelines, each of which may contain a queue of instructions.

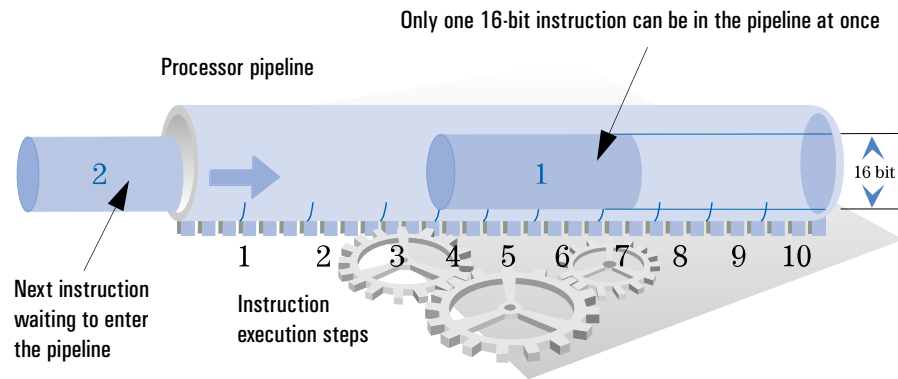
With 32-bit instructions, the processor will keep the pipeline's queue full; as an instruction progresses down the pipeline, another will be loaded in behind it. With each pulse of the processor's internal clock, all instructions will move one stage further down the queue. The result of using this mechanism is that one instruction can be completed by each pipeline with each pulse of the clock.



Why 16-bit Applications are Slower

When executing 16-bit instructions, the Pentium Pro processor is limited by two constraints. First, the Pentium Pro cannot mix 32-bit and 16-bit instructions in a pipeline. Second, at any moment only one 16-bit instruction can normally be present in a pipeline.

When running a 16-bit application, all instructions are 16-bits and so each instruction is executed singly, without use of the pipeline's queuing facility. In effect, the pipeline is not used. Since the pipeline is the processor's most important means of accelerating instruction execution, the negative impact on performance is significant.



NOTE

For the reasons explained above, HP does not recommend using your PC to run 16-bit applications. Best performance can only be obtained when running 32-bit applications.

1 Your PC's Performance Features

Benefits of 32-bit Applications

Which Applications are 16-bit? All Windows for Workgroups applications are 16-bit. Many older applications, that have been adapted for use under Windows 95, Windows NT, or OS/2, may also be 16-bit. Refer to the manual supplied with your application software for more details.

Which Applications are 32-bit? All applications written specifically for Windows NT, Windows 95 or OS/2 are 32-bit. Some examples are listed below.

Windows NT/Windows 95 applications:

- MS-Office for Windows 95
- MS-Access for Windows 95
- Adobe Photoshop™ 3.0

OS/2 Applications:

- Lotus Notes
- Lotus Freelance

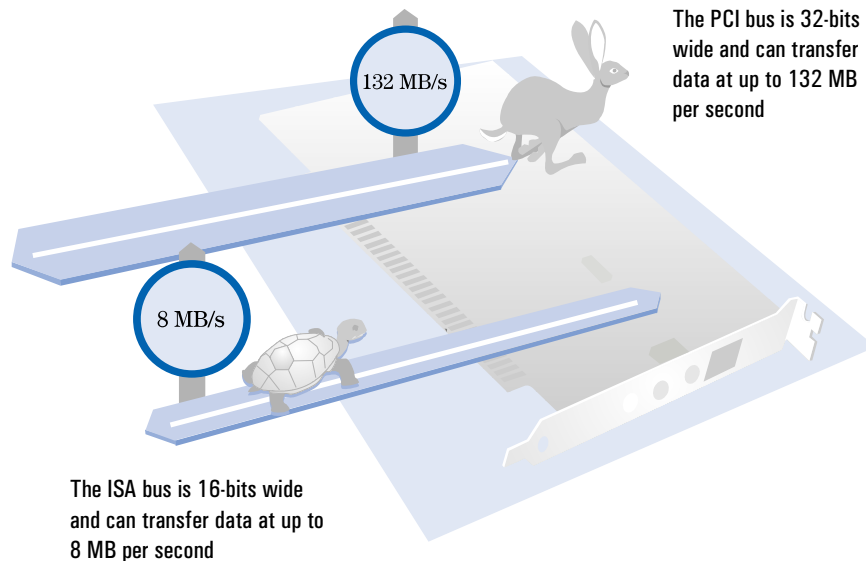
Installing Fast Peripherals on the PCI Bus

The HP Vectra XU PC provides six slots for accessory boards. Two of these slots are already occupied by your advanced graphics controller and LAN controller. The remaining four slots are available for installing accessory boards and can be used to add extra peripheral devices to your PC. These slots are of two different types.

The PCI Bus

Your PC uses the Peripheral Component Interconnect (PCI) bus as the main channel for connecting peripheral devices. Your PC also provides an Industry Standard Architecture (ISA) bus for backwards compatibility with any ISA accessory boards you may need to use.

The difference in performance between the PCI bus and the ISA bus is significant; the PCI bus can transfer data more than 16 times faster than the ISA bus.



1 Your PC's Performance Features

Installing Fast Peripherals on the PCI Bus

| | |
|---|---|
| Your PC's Accessory Board Slots | Three of your PC's accessory board slots are for full-length, 32-bit PCI accessory boards. Two of these are occupied by the video adapter and LAN interface board. Two more slots are for full-length, 16-bit ISA accessory boards. The sixth slot is a combination slot and can be used for either a full-length, 16-bit ISA accessory board or a full-length, 32-bit PCI accessory board. |
| Which Peripherals Can Benefit From The PCI Bus? | <p>Any peripheral that needs to exchange large quantities of data with your PC's processor or memory will benefit from the bandwidth (data handling capability) of the PCI bus. For this reason your PC's integrated SCSI controller, integrated IDE controller, video adapter and networking board are all installed on the PCI bus.</p> <p>If you need to install an accessory board in your PC, HP recommends that the PCI bus is your first choice for expansion.</p> |
| PCI Plug and Play | The PCI standard supports Plug and Play, which means easy configuration for installed peripherals. If you install an extra PCI accessory board, the board will be configured for use automatically. |
| Low Power Migration | The PCI bus in your PC supports PCI accessory boards that use two different power sources, 3.3 volts or 5 volts. Most currently available PCI accessory boards use the 5 volt power source. Accessory boards that use the 3.3 volt power source use less power, which helps to reduce the overall power consumption of your PC. As more 3.3 volt PCI accessory boards become available, you will be able to install these inside your PC immediately. |
| PCI Clock Speeds | <p>The PCI bus in your PC uses a clock that is half the speed of your processor's local bus. This means that your PCI bus uses a clock of either 30 MHz or 33 MHz, depending on your processor.</p> <p>At 30 MHz, the PCI bus can transfer up to 120 MB of data each second, while at 33 MHz, the transfer rate is 132 MB each second.</p> |

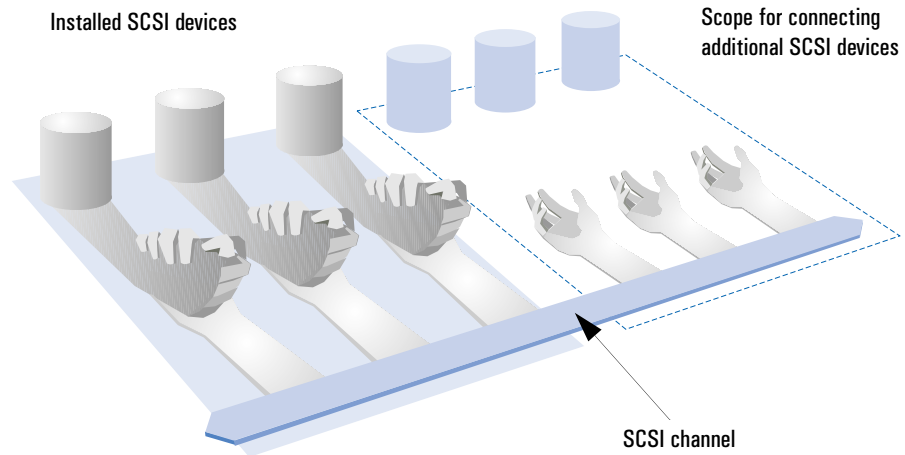
Increasing the Speed Limit With Ultra SCSI

Your HP Vectra XU PC integrates an advanced SCSI controller for connecting mass storage devices. This SCSI controller provides a high-capability SCSI channel with two connections: one on your PC's system board for connecting internal SCSI devices; and one on your PC's rear panel for connecting external SCSI devices.

SCSI Interface Standards

The Small Computer System Interface (SCSI) standard offers the highest level of peripheral connectivity available to a PC. The SCSI channel in your PC can connect up to seven mass storage devices, both internal and external. Up to five of these devices can be installed inside your PC.

The SCSI standard is highly flexible, enabling devices of different types and capabilities to be connected on the same channel. Communication between the SCSI controller and a SCSI device is based on a request-acknowledge protocol ("handshaking"), with each device (including the controller) having a SCSI address for identification.



1 Your PC's Performance Features

Increasing the Speed Limit With Ultra SCSI

Multithreaded Operating System Support

The PCI SCSI controller in your PC offers additional performance advantages under multithreaded operating systems. Your PC's integrated SCSI controller is capable of receiving and processing the multiple commands issued by a multithreaded operating system. The SCSI controller is also able to re-order operating system commands to obtain the most efficient execution order.

Ultra SCSI-Ready

The SCSI channel in your PC supports the latest SCSI standard, Ultra SCSI, which gives data transfer rates of up to 20 MB per second. As new mass storage devices supporting this standard become available, you will be able to make use of them immediately. Installing an Ultra SCSI device in your PC will offer a performance improvement over previous generation SCSI devices.

Investment Protection

Use of the high speed Ultra SCSI transfer rates does not exclude the connection of slower SCSI devices on your PC's SCSI channel. Mixing SCSI devices of different generations will not cause any conflicts in your PC's operation.

Three types of 8-bit SCSI devices are supported:

- SCSI-1 devices
These are first generation SCSI devices and support data transfer rates of up to 5 MB/s.
- SCSI-2 devices
The previous generation of SCSI devices that support data transfer rates of up to 10 MB/s.
- Ultra SCSI devices
The latest SCSI devices. These support data transfer rates of up to 20 MB/s.

Your PC's advanced SCSI controller can manage SCSI devices of all three types simultaneously.

When installing a SCSI device, the data transfer rate for that device must be configured correctly. SCSI data transfer rates can be set independently for each SCSI device installed using the *SCSISelect* Utility. Refer to your *User's Guide* for information on this Utility.

Automatic
Configuration

Your PC is able to configure many SCSI mass storage devices automatically through a new feature, SCSI Configured Automatically (SCAM). When installing SCSI devices, refer to the documentation supplied with the device to see if it supports this feature. SCSI devices which do not support this feature will probably need jumpers to be set for their configuration.

To make use of the SCAM feature:

- 1 Turn off your PC.
- 2 Turn on any external SCSI devices connected to your PC.
- 3 Turn on your PC.

Any SCSI device connected to your PC which supports SCAM will be configured automatically by your PC's SCSI BIOS.

You can confirm that new SCSI devices have been correctly configured with the SCSISelect Utility. Refer to the *User's Guide* supplied with your PC for information on this Utility.

Flexibility

The SCSI controller in your PC provides a number of new features to make your mass storage configuration more flexible. Among these features is the ability to select any SCSI hard disk or CD-ROM drive as the boot drive when using Windows 95.

You can select your PC's boot drive through the built-in Setup program. For more information on your PC's Setup program, refer to your PC's *User's Guide*.

NOTE

By default, your PC is set to boot from an IDE hard disk drive. If you have both SCSI and IDE hard disk drives installed, your PC will only boot from an IDE hard disk drive when using the following operating systems: Windows for Workgroups; Windows NT; or OS/2.

1 Your PC's Performance Features

Increasing the Speed Limit With Ultra SCSI

The External SCSI Connection

The external SCSI connector on your PC's rear panel can be used to connect external SCSI devices like tape drives. Use of the external connector will be detected automatically by your PC at power-on.

On detecting that the external SCSI connector is in use, your PC will automatically:

- disable the SCSI terminator on your PC's system board
- disable Ultra SCSI data transfer rates for all SCSI devices.

How to enable Ultra SCSI

The use of Ultra SCSI (20 MB/s transfer rate) imposes restrictions on SCSI bus traffic. By default, the system BIOS will ensure data integrity by automatically disabling Ultra SCSI (reducing the transfer rate to 10 MB/s transfer rate) whenever an external SCSI device is connected.

You can change the default setting so that Ultra SCSI is always enabled, even when an external SCSI device is connected. To do this, go to the **Integrated SCSI Interface** section of the setup program and change the **Ultra SCSI** field to **Enabled**. Use this setting with caution and only when you are familiar with the Ultra SCSI restrictions.

When connecting SCSI devices, it is recommended that you observe the following overall cable length restrictions.

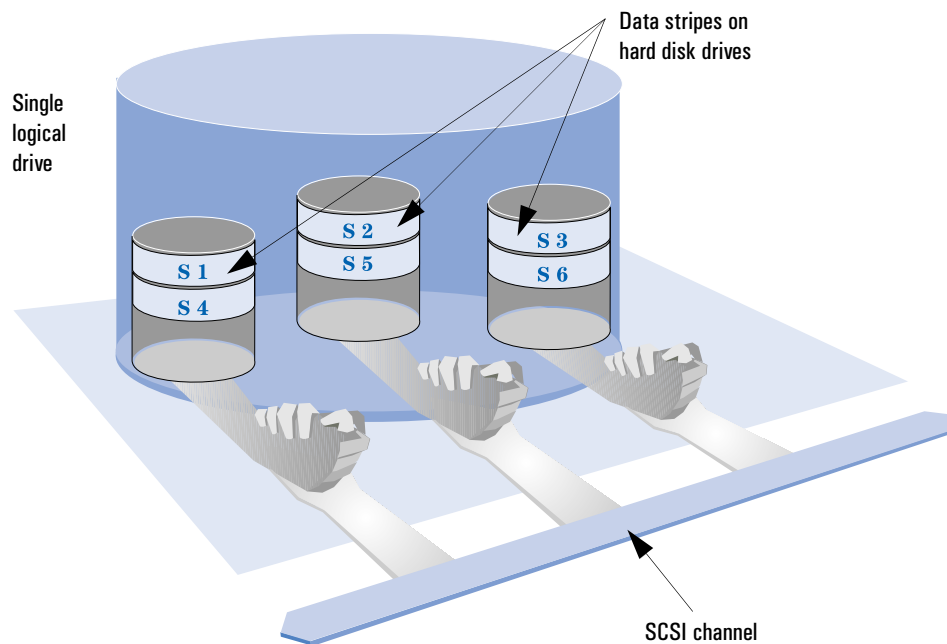
| Configuration | Maximum Recommended Cable Length |
|--|----------------------------------|
| Ultra SCSI operation (20 MB/s) with up to three devices connected | 3 m |
| Ultra SCSI operation (20 MB/s) with four or more devices connected | 1.5 m |
| SCSI-2 operation (10 MB/s) with up to seven devices connected | 6 m |

NOTE

When you turn on your PC, be sure to turn on any external SCSI devices first. Failure to do this may result in your external SCSI devices being incorrectly detected by your PC.

Disk Striping

If you are using Windows NT, your PC's integrated SCSI controller is able to improve the performance of your SCSI hard disk drives by using disk striping. This is a method of grouping multiple disk drives together so that they seem, to the user, as a single (logical) disk. Data is stored across these multiple disk drives in stripes of equal size; the first stripe is stored on the first drive in the group, the second stripe on the second drive and so forth.



The advantage of disk striping is that it significantly reduces the impact of your disk drives' main performance limitation which is the interface between the SCSI channel and the hard disk drive.

1 Your PC's Performance Features

Increasing the Speed Limit With Ultra SCSI

When your PC writes data to a particular SCSI hard disk drive, that data passes from the integrated SCSI controller to a buffer on the disk drive. The drive then transfers the data from the buffer on to the disk. Before transferring more data to the disk drive buffer, the integrated SCSI controller must wait until the previous data has been transferred on to the disk.

By using disk striping, your PC's integrated SCSI controller can avoid this wait, by making the next data transfer to the next disk drive in the striping group. Before transferring more data to the first drive, the controller will transfer data to each of the other drives in the striping group. Because successive data transfers are to different drives, the time between data transfers to any individual drive is increased and so the delaying effect of the buffer-to-disk transfer is removed.

Can You Use Disk Striping?

Disk striping is only available with Windows NT. Refer to the manual supplied with this operating system for information on how to make use of this feature. Disk striping may also be available for your PC's IDE hard disk drives.

NOTE

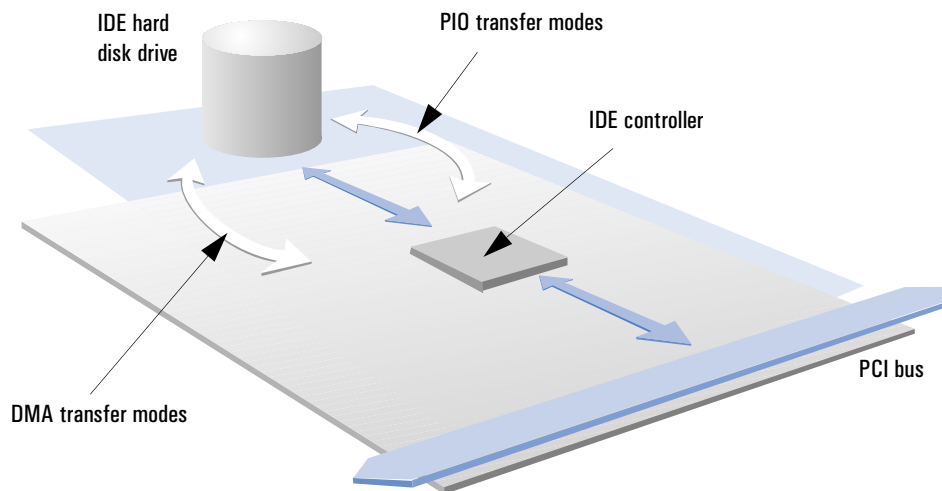
To enable disk striping on a group of hard disk drives, all the drives in the group must be of identical type and capacity. Enabling striping on a group of disks of different types may produce unexpected results.

Making the Most of Your PC's IDE Channels

Your PC integrates an advanced IDE controller for connecting internal mass storage devices. This controller can manage the operation of up to four IDE devices and supports both hard disk and CD-ROM drives.

Your PC's IDE Channels Your PC's integrated PCI IDE controller provides two Fast IDE channels for connecting IDE mass storage devices. Each channel can be used for connecting up to two IDE devices. Both IDE channels support the highest data transfer rates currently available and offer optimized performance with any combination of IDE devices.

PIO and DMA Modes The PCI IDE controller uses two different techniques to transfer data with IDE devices: Programmed Input/Output (PIO) modes and Direct Memory Access (DMA) modes. When transferring data to or from an IDE device, the IDE controller will automatically select the technique that is most suited to the transfer.



1 Your PC's Performance Features

Making the Most of Your PC's IDE Channels

The IDE controller transfers data to or from IDE devices in response to data transfers received or requested on your PC's PCI bus. The technique used for a particular data transfer with an IDE device is chosen according to the type of transfer received or requested on the PCI bus. In this way, the IDE controller ensures that data transfers are optimized between the PCI bus and the IDE device.

Your PC's IDE controller supports five PIO modes, PIO Mode 0 - 4, and three DMA modes, DMA Mode 0 - 2. Higher numbered modes offer increased data transfer rates than lower numbered modes. Not all IDE devices support all of these modes. When transferring data with an IDE device, the integrated IDE controller will select the highest numbered mode supported by the IDE device.

Data transfer rates for all of these modes are given in the table below.

| Transfer Mode | Maximum Transfer Rate |
|---------------|-----------------------|
| PIO Mode 0 | 3.33 MB per second |
| PIO Mode 1 | 5.22 MB per second |
| PIO Mode 2 | 8.33 MB per second |
| PIO Mode 3 | 11.1 MB per second |
| PIO Mode 4 | 16.7 MB per second |
| DMA Mode 0 | 4.2 MB per second |
| DMA Mode 1 | 13.3 MB per second |
| DMA Mode 2 | 16.7 MB per second |

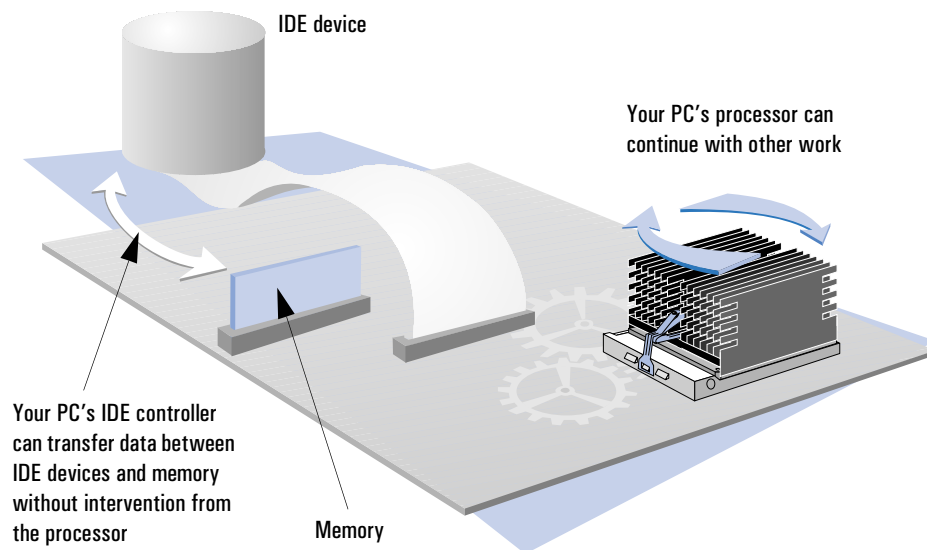
PCI Master Capability

The integrated IDE controller transfers data with your PC's processor and memory through the PCI bus. PCI devices fall into two categories: slaves and masters. A PCI slave is a device that can only respond to transfers or requests made by another PCI device — it cannot initiate transfers. A PCI master is able to initiate transfers and to take control of the PCI bus while a transfer is being made.

Your PC's integrated IDE controller can be configured as either a PCI master or a PCI slave. As a PCI master, the IDE controller will give a significantly improved performance for data transfers on the PCI bus. Typical PCI transfer rates are greater than 15 MB per second (with a maximum of 16.7 MB/s) when operating as a PCI master, compared with up to 5 MB per second as a PCI slave.

When configured as a PCI master, your PC's IDE controller helps to improve the overall performance of your PC in two ways:

- ❑ PCI masters can begin and interrupt their PCI data transfers according to the demands of other PCI data traffic. As a PCI master, your PC's IDE controller works with other PCI devices to give maximum PCI bandwidth.
- ❑ As a PCI master, the IDE controller can transfer data to and from memory without intervention from your PC's processor. This means that the processor is free to continue with other work.



You can configure your PC's IDE controller as a PCI master through the IDE driver used by your operating system. For more information on your operating system's IDE driver, refer to the manual supplied with your operating system.

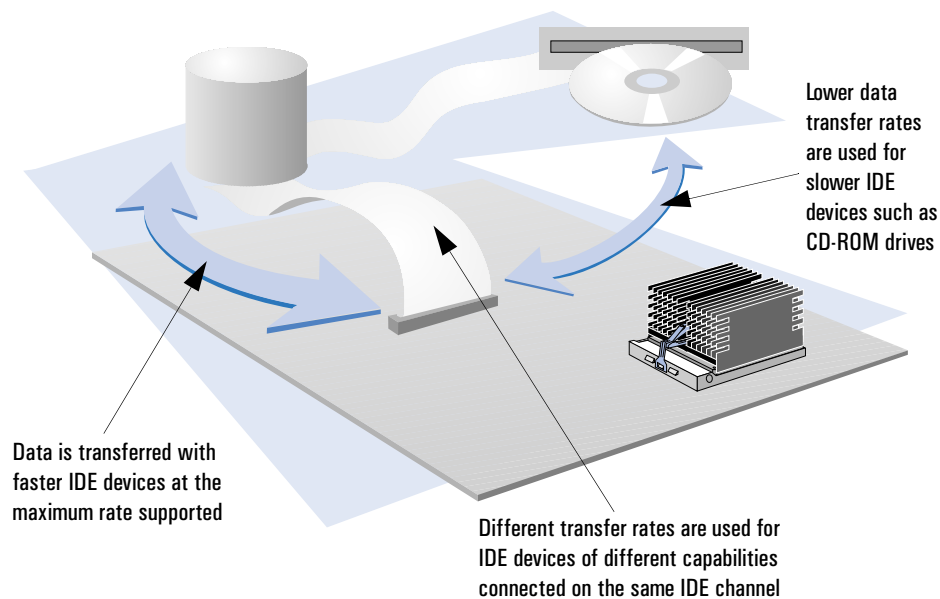
1 Your PC's Performance Features

Making the Most of Your PC's IDE Channels

Optimized Timings

Different IDE devices have different data transfer capabilities. The latest IDE hard disk drives support PIO Mode 4 and DMA Mode 2 timings, but older hard disk drives and CD-ROM drives will typically support only the lower modes.

To give maximum performance with any combination of IDE devices, your PC's IDE controller supports split-mode timing on both IDE channels. This means that it is able to transfer data at different rates with different devices on the same IDE channel. Split mode timing enables you to gain all the performance advantage from the latest generation IDE devices, without compromising your ability to connect slower devices.



More Video Performance

Highest Graphic Performance

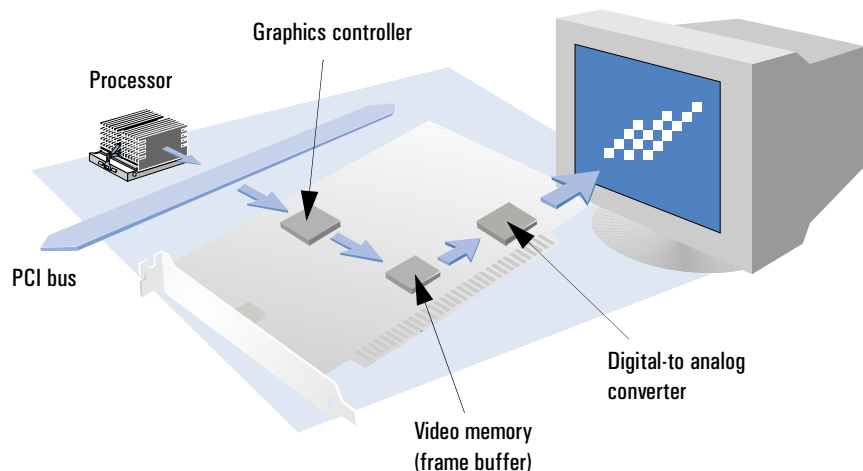
Your PC's Millennium Video Adapter offers the highest video performance currently available for a PC. The Video Adapter provides all the latest graphic acceleration features as well as MPEG-1 software support for high quality video playback.

The Millennium Video Adapter gives optimized performance with Graphic User Interfaces (GUIs), such as any of the Windows operating systems. Integrated hardware graphic acceleration is used at all supported resolutions and color-depths, while integrated color-space conversion enables accelerated video playback.

Your Video Controller

Your Millennium Video Adapter consists of three main components:

- A graphics controller, which decodes data received from your PC's processor and converts it into pixel data for your display
- Video memory (frame buffer), where the pixel data is stored by the graphics controller
- A digital-to-analog converter (DAC), which reads the pixel data from the video memory and converts it into analog signals for your display.



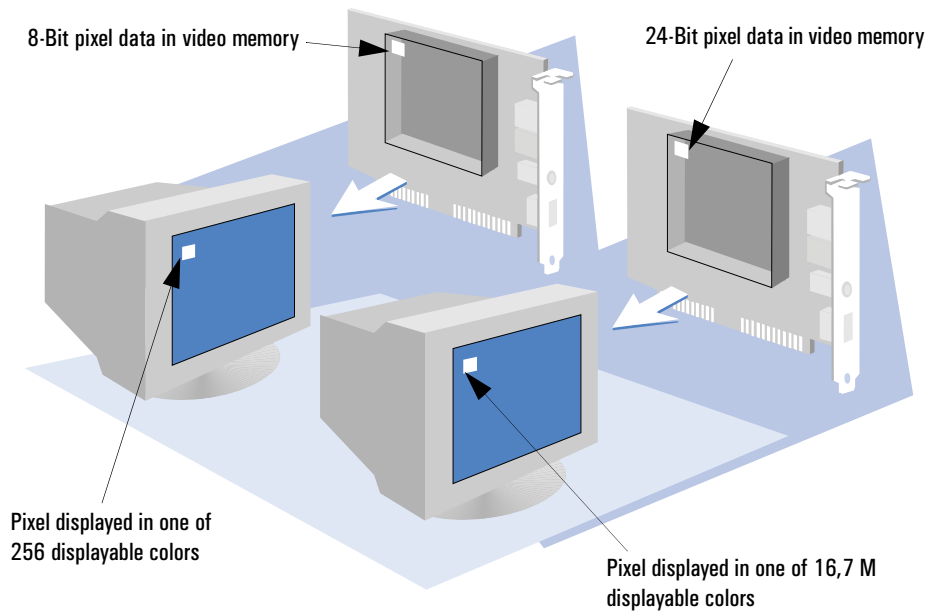
1 Your PC's Performance Features

More Video Performance

The graphics controller stores screens of data for output to the display in video memory. These screens of data are called frames and so your video memory is also known as a frame buffer.

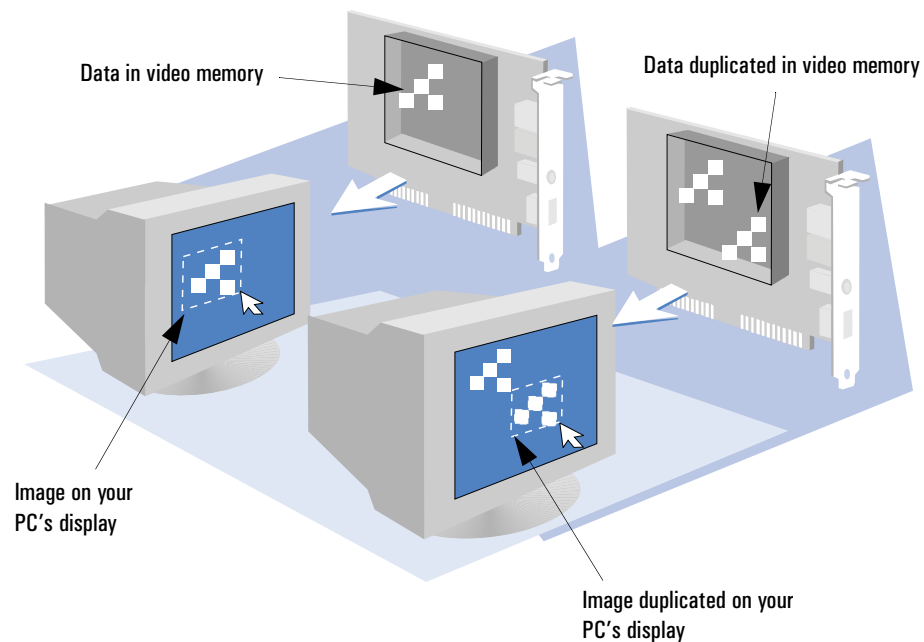
Pixel Data

The pixel data stored by the graphics controller defines the color to be displayed for each pixel. The amount of data required for each pixel is determined by the number of displayable colors; if you are using only 256 displayable colors, each pixel needs eight bits to define its color (eight bits gives 256 possible combinations), while in true color modes, each pixel can require up to four bytes (32-bits).



The screen resolution determines how many pixels make up a screen for the display. The number of pixels required is typically very large. Even a standard VGA screen at 640×480 resolution consists of over 300,000 pixels. Consequently, when writing a screen of pixel data to the video memory, the video controller is manipulating very large amounts of data.

Hardware Acceleration Many operations performed by your graphics controller involve the manipulation of pixel data stored in the video memory. For example, if you are using a graphics application and want to duplicate a part of an illustration, you will probably select the required area with your mouse and use a copy/paste function. To display your modified illustration, the graphics controller will locate the pixel data representing the area to be copied (in the video memory) and duplicate it in another part of the video memory.



To speed up the manipulation of pixel data, the graphics controller on your Millennium Video Adapter provides a number of graphic acceleration features. These features allow the graphics controller to map areas of video memory to other areas of video memory using simple algorithms. If you copy, rotate, stretch or transform a graphic item on your display, you will be making use of these features.

1 Your PC's Performance Features

More Video Performance

The Millennium Video Adapter also implements acceleration for color-space conversions. This enables the real-time acceleration of video playback.

By implementing these acceleration features through hardware the Millennium Video Adapter ensures that they are always available, whatever the operating system, application, or video driver.

WRAM Video Memory The key to your Millennium Video Adapter's high performance is the type of video memory it uses: Windows RAM (WRAM). This is a dual-ported memory, with dedicated interfaces for both the input of pixel data from the graphics controller and the output of data for your display.

The advantage of WRAM is that it allows both ports to operate simultaneously, meaning that it can receive new pixel data to be displayed while outputting existing data to the display. This makes WRAM up to 50% faster than previous types of video memory.

Increasing Video Memory The Millennium Video Adaptor is supplied with 2 MB of WRAM video memory. This can be increased to 4 MB or 8 MB by fitting an additional 2 MB WRAM or 6 MB WRAM memory module. The 2 MB WRAM module can be ordered from HP. Contact your dealer for information about the 6 MB WRAM module.

The amount of WRAM video memory installed on the Millennium Video Adapter determines the resolutions and number of colors your PC is able to display. At any resolution, the amount of pixel data needed to define an entire screen is equal to the total number of pixels to be displayed multiplied by the amount of data required for each pixel.

Increasing your display resolution will increase the total number of pixels needed to define an entire screen. Similarly, increasing the number of displayable colors will increase the amount of data required for each pixel. Increasing either of these parameters will increase your requirement for video memory.

Available video resolutions for the Millennium Video Adapter and the quantity of video memory required for these video resolutions are indicated in the following table.

| Resolution: | Video memory required for these colors: | | |
|-------------|---|-------------------------|-----------------------------|
| | 256 colors | 64 K colors hi-color | 16.7 M colors true-color |
| 640 × 480 | 2 MB | | |
| 800 × 600 | 2 MB | | |
| 1024 × 768 | 2 MB | | 4 MB |
| 1152 × 882 | 2 MB | | 4 MB |
| 1280 × 1024 | 2 MB | 4 MB | |
| 1600 × 1200 | 2 MB | 4 MB | 8 MB |

For more information on installing additional video memory, refer to the *User's Guide* supplied with your PC.

MPEG-1 Support

MPEG is a standard for the transmission of video data. A video MPEG module is available for your Millennium Video Adapter that will enable you to decode MPEG-1 data for output to your display. By using this feature you will be able to playback full-screen, full-motion video on your PC's display.

The video MPEG module cannot be ordered from HP. Contact your dealer for more information about this accessory.

1 Your PC's Performance Features

More Video Performance

Ergonomic Refresh Rates

The video controller must redraw your display at frequent intervals. The frequency with which it does this is called the video refresh rate and higher rates are less tiring on the eyes than lower rates.

The Millennium Video Adapter supports video refresh rates of up to 200 Hz for flicker free displays. The 200 Hz refresh rate supported by the MGA Video Adapter is nearly twice the rate used by typical Ultra VGA controllers, making it one of the most ergonomic video controllers currently available.

The video refresh rate used will be determined by the video resolution selected and the capabilities of your display. The following table shows the maximum video refresh rates that can be used.

| Video resolution | Maximum refresh rate |
|------------------|----------------------|
| 640 × 480 | 200 Hz |
| 800 × 600 | 200 Hz |
| 1024 × 768 | 120 Hz |
| 1152 × 882 | 120 Hz |
| 1280 × 1024 | 110 Hz |
| 1600 × 1200 | 85 Hz |

Refer to your PC's *User's Guide* for more information on available video resolutions and refresh rates.

Your PC's Audio Resources

Your PC's Audio Capabilities

Your PC provides stereo SoundBlaster™ 16 audio capability integrated on the system board. The audio subsystem provides a number of connections for use with external devices, including musical instruments through a MIDI (Musical Instrument Direct Interface) connector. Your PC's audio resources offer you:

- 16-bit, CD-quality stereo recording and playback
- Record and playback capability at frequencies between 5 KHz and 44.1 KHz
- MIDI and MPC2 compatibility
- Software controlled stereo mixer capable of:
 - selecting multiple recording sources
 - providing variable input and output gain levels on each channel
- Built-in stereo amplification
- FM synthesizer with 20 polyphonic voices.

FM Synthesis

The embedded FM synthesizer uses FM-OPL3 synthesis to create musical sounds through a series of internal oscillators. The sounds you hear are generated by an algorithm applied to the 20 polyphonic voices.

1 Your PC's Performance Features

HP PCI Integrated 10/100BT LAN Interface

HP PCI Integrated 10/100BT LAN Interface

The 32-bit PCI LAN controller provides a 10BaseT/100BaseTX fast Ethernet interface. This interface uses either IEEE 802.3 technology for transmitting at 10 Mbit/s, or IEEE 802.3u technology for transmitting at 100 Mbit/s.

Best performance from your system's integrated 10/100BT LAN interface is obtained when using the 100 Mbit/s transmission rate. This transmission rate is over 10 times the transmission rates used by standard 10BaseT networks.

Your Network Adapter Your PCI integrated 10/100BT LAN interface requires no hardware configuration. Drivers are supplied with your system that will enable you to use the network adapter with any type of network for all supported operating systems.

For further information on the HP PCI integrated 10/100BT LAN interface, refer to the *Network Administrator's Guide* supplied with your PC.

HP PCI Integrated 10/100VG LAN Interface

The 32-bit PCI LAN controller provides a 10Base-T/100VG AnyLAN interface. This interface uses either IEEE 802.3 technology for transmitting at 10 Mbit/s, or IEEE 802.12 technology for transmitting at 100 Mbit/s.

Best performance from your PC's integrated 10/100VG LAN interface is obtained when using the 100 Mbit/s transmission rate. This rate is over 10 times the transmission rates used by standard 10Base-T networks and offers support for time-sensitive applications such as multimedia presentations.

No Data Collisions

The HP PCI integrated 10/100VG LAN interface uses a protocol called Demand Priority Access to avoid network collisions. Under this protocol, data packets transmitted over the network are directed only to their destination port. The data is not visible to other ports on the network.

By using Demand Priority Access, you will be able to prioritize the data traffic on your network and avoid collisions between different data packets. Demand Priority Access allows you to minimize latency (unused capacity) on your network and so maximizes network throughput for time-sensitive applications.

Your Network Adapter

Your PCI integrated 10/100VG LAN interface requires no hardware configuration. Drivers are supplied with your PC that will enable you to use the network adapter with any type of network for all supported operating systems.

For further information on the HP PCI integrated 10/100VG LAN interface, refer to the online *Network Administrator's Guide* supplied with your PC.

1 Your PC's Performance Features

Performance Topic/Configuration Cross-Reference

Performance Topic/Configuration Cross-Reference

The following table shows which category of configuration change is required to obtain the full performance benefits discussed in this chapter. Where different types of configuration change are indicated for a topic, these may refer to different performance benefits: for full details, refer to the performance topic.

| Performance Topic | Adjusting Your PC's Setup Parameters | Installing Accessories | Changing Software Configuration Parameters |
|---|--------------------------------------|------------------------|--|
| Improving the performance of your PC's processor (page 4) | | ✓ | |
| Advantages of dual processor configurations (page 7) | | ✓ | ✓ |
| Matching memory capacity to your requirements (page 15) | | ✓ | ✓ |
| Benefits of 32-bit applications (page 21) | | | ✓ |
| Installing fast peripherals on the PCI bus (page 25) | | ✓ | |
| Increasing the speed limit with Ultra SCSI (page 27) | ✓ | ✓ | ✓ |
| Making the most of your PC's IDE channels (page 33) | ✓ | ✓ | ✓ |
| More video performance (page 37) | ✓ | ✓ | ✓ |
| Your PC's audio resources (page 43) | | ✓ | ✓ |
| HP PCI Integrated 10/100BT LAN Interface (page 45) | | | ✓ |

Technical Reference

This chapter describes the hardware architecture of your HP Vectra PC and explains how the latest advances in component technology have been harnessed to bring extra power to your desktop application.

Architectural Overview

Bus architecture

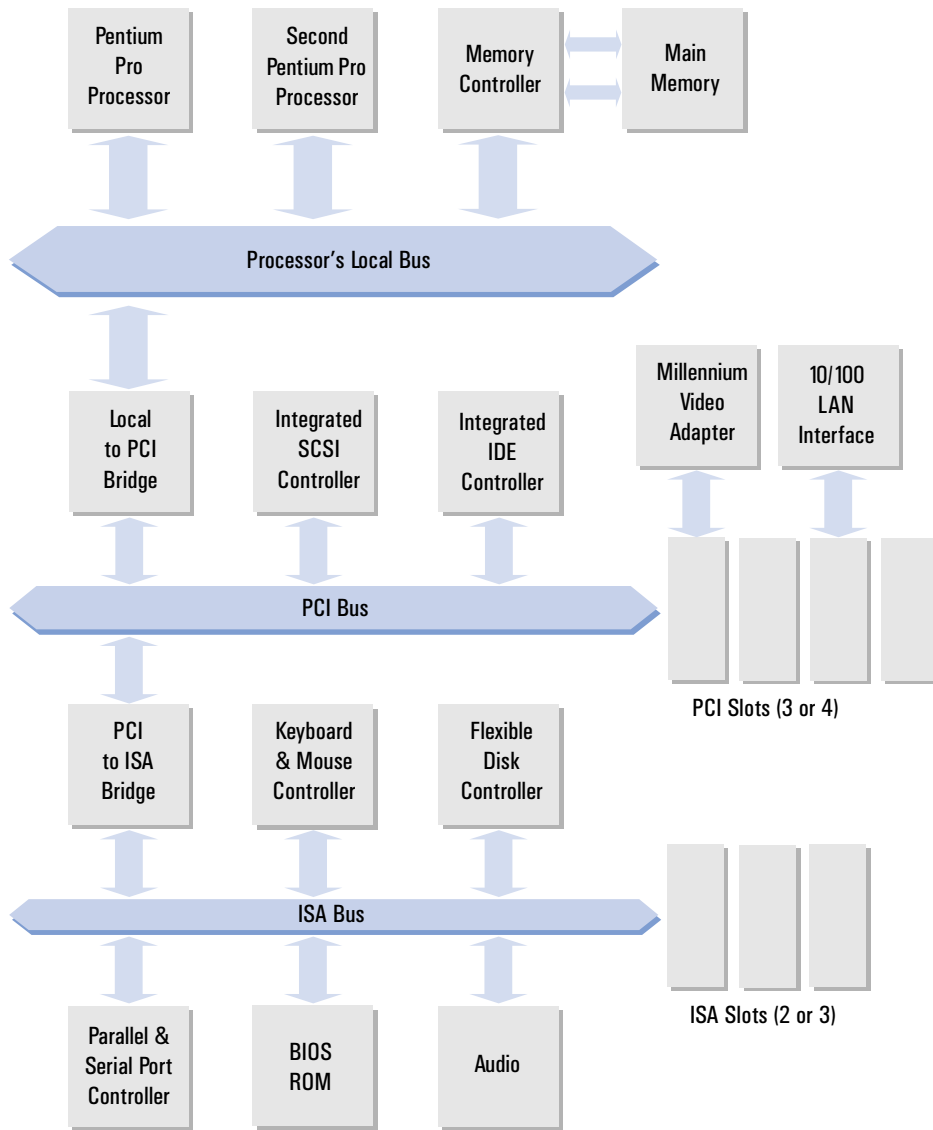
Your HP Vectra XU PC is based on a three-bus architecture. Each bus connects functional components of your PC which have similar data handling requirements. By using this architecture, your PC is able to distribute its data traffic more effectively. The three buses are:

- The (processor's) local bus, which connects the Pentium™ Pro processor with main memory. This bus operates at 60 or 66 MHz (depending on your processor) and is 64-bits wide. The local bus has the highest data handling capacity of any data path in your PC.
- The PCI bus, which connects I/O peripherals requiring high data throughput. Your PC's integrated SCSI controller and IDE controller are connected to this bus, as are your video adapter and LAN interface board. The PCI bus operates at either 30 or 33 MHz (depending on your processor) and is 32-bits wide.
- The ISA bus, which connects slower I/O peripherals such as your keyboard/mouse controller, flexible disk controller and BIOS ROM. The ISA bus operates at 7.5 or 8.3 MHz (depending on your processor) and provides backwards compatibility with previous generation accessory boards.

Bridges

The three buses are connected together by a series of components called bridges. Each bridge converts data, passing in either direction, to the format required by the destination bus. The bridge devices are highly buffered to accelerate their operation.

The block diagram on the facing page illustrates this architecture of your HP Vectra PC in functional components. The descriptions given in the rest of this chapter describe some of these components, with special emphasis on new features and technologies.



2 Technical Reference

The Intel Pentium Pro Processor

The Intel Pentium Pro Processor

Your PC uses the latest development in x86 family processors, the Intel Pentium Pro. This processor implements a number of new features, such as superpipelining and an integrated level-two cache. It offers a performance that is almost twice that of a Pentium processor operating at the same external clock speed.

Your PC is supplied with one Pentium Pro processor as standard, but also provides a socket for installation of a second Pentium Pro processor. If you are using an operating system that supports the Intel Multiprocessor Specification (MPS), you can improve your PC's processing performance by installing a second processor.

Characteristics

The Pentium Pro processor uses a 64-bit external data path and a 36-bit address bus. It integrates two 8 KB level-one cache memories (one for instructions, one for data) and a 256 KB level-two cache. Internally it uses three pipelines and five execution units for instruction execution.

The table below summarizes the Pentium Pro's characteristics and compares them with those of the Intel Pentium processor.

| | Intel Pentium Pro | Intel Pentium |
|------------------------|-----------------------------|-----------------------------|
| Data bus | 64-bit | 64-bit |
| Address bus | 36-bit | 32-bit |
| Level-one cache | 8 KB data, 8 KB instruction | 8 KB data, 8 KB instruction |
| Level-two cache | 256 KB | None |
| Superscalar design | Three-way | Two-way |
| Execution units | Five | Three |
| Branch prediction | Advanced dynamic | Dynamic |
| Speculative execution | Yes | No |
| Out-of-order execution | Yes | No |

Superpipeline Architecture

- Three Pipelines** The key to the Pentium Pro processor's improved performance is its superpipelined architecture, which allows it to execute instructions more quickly. Each instruction is executed in a number of steps through a mechanism called a pipeline. In fact the Pentium Pro processor uses three pipelines, which allows it to execute more than one instruction simultaneously. Each Pentium Pro's pipeline consists of up to 14 individual steps.
- Pipelines have been used by previous generations of PC processors, such as the i486™ and the Pentium, to accelerate instruction execution. The reason for this is that x86 compatible instructions require a number of separate operations to complete. By using a pipeline, these processors are able to queue instructions through the individual operations so that one instruction can be completed with each clock cycle.
- Micro-ops** The Pentium Pro processor takes the pipeline approach one stage further, by breaking the x86 instructions down into simpler operations called micro-ops. These micro-ops are then executed through the Pentium Pro's pipelines. The micro-ops are much simpler to handle than x86 instructions, and allow the Pentium Pro processor more flexibility in the way it executes them. The Pentium Pro can reorder the micro-ops within its pipelines for greater efficiency and can frequently execute multiple micro-ops in parallel.
- Multiple Execution Units** The core step in a processor pipeline is the execution unit; this is where the real work is done. The pipeline steps before the execution units are mostly concerned with preparing the instruction for execution. The steps after the execution units involve the re-assembly of data and addresses. The Pentium Pro provides five execution units, giving it increased flexibility for instruction execution.
- To ensure that the pipelines are used to their greatest efficiency, the Pentium Pro must keep its instruction units busy. For this reason, the Pentium Pro implements two additional features for instruction execution: out-of-order execution; and speculative execution.

2 Technical Reference

The Intel Pentium Pro Processor

Out-of-order Execution When executing x86 family instructions, previous generations of processors had to be faithful to the order in which the instructions were received. This meant that if a particularly slow or complicated instruction was being executed, the processor was obliged to stall its pipeline until the instruction had completed.

By breaking instructions down into micro-ops, the Pentium Pro is able to change the order in which it executes instructions. When a particular instruction requires longer than average to execute, the Pentium Pro will fetch and execute another instruction while waiting for the first instruction to complete. The status of the first instruction is stored in registers while the new instruction is executed, ensuring that no conflicts arise. This facility is called out-of-order execution, and ensures that the Pentium Pro's three pipelines are used to their greatest effect.

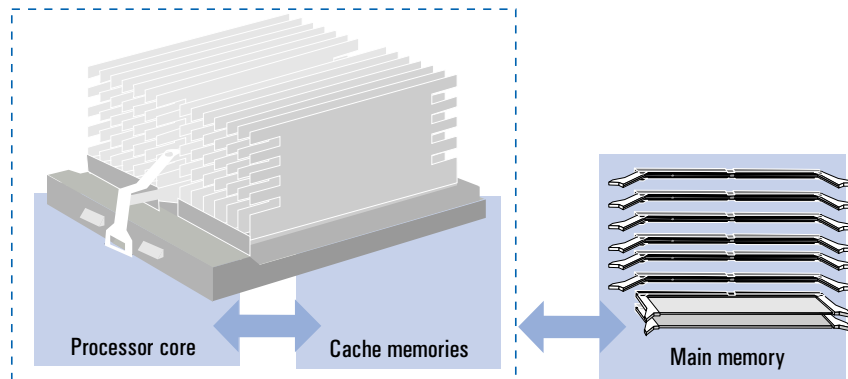
Speculative Execution All programs contain branches. These are produced by conditional instructions which can change the thread of instruction execution. Depending on the conditions when a conditional instruction is executed, different instructions will be required next by the program.

Like the Pentium processor, the Pentium Pro provides a branch prediction unit that can identify program branches and load their instructions into the level-one instruction cache memory. However, unlike the Pentium, the Pentium Pro is also able to execute these instructions in case they are needed. This feature is called speculative execution, and it can significantly reduce the time required for program branches.

Integrated Cache Memory

Cache memories are used by processors to accelerate access times for frequently used data and instructions. A cache is located between the processor and main memory, and stores copies of the last data read or written by the processor. If the same data is requested again by the processor, it will be supplied from the cache at significantly reduced access time.

Pentium Pro processor



Cache memory has a much smaller capacity than main memory and stores not only data, but also the memory addresses that correspond to the data. When the processor reads or writes data in memory, the address for that data is compared with the addresses stored in the cache. If a match is found, the cache registers a cache hit and the data will be read or written directly from or to the cache. If a match is not found, a cache miss occurs and the cycle will be passed to main memory with no time penalty.

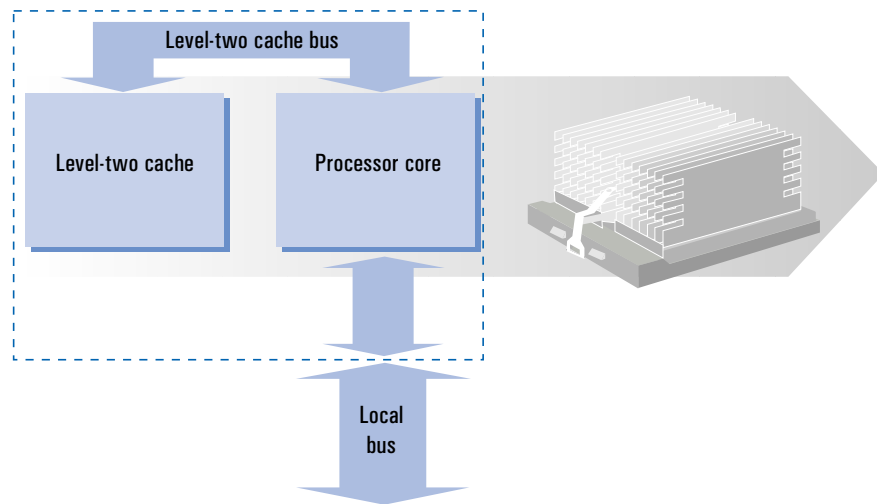
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The Intel Pentium Pro Processor

| | |
|--------------------------------|---|
| Two levels of Integrated Cache | The Pentium Pro processor integrates three cache memories in the same package: an 8 KB level-one data cache; an 8 KB level-one instruction cache; and a 256 KB unified level-two cache. The cache level refers to the proximity of the cache to the processor's pipelines; the level-one caches are closer to the pipelines than the level-two cache. The caches are hierarchical, so that any data or instructions stored in level-one cache memories will also be stored in the level-two cache memory. |
| Level-One Caches | The Pentium Pro's two 8 KB level-one caches are similar to the level-one caches integrated in the Pentium processor. Both level-one caches use a two-way set-associative organization, meaning that they consist of two, separate logical banks of equal size (4 KB each). |
| Level-Two Cache | The Pentium Pro's 256 KB level-two cache stores both data and instructions. The level-two cache uses a four-way set-associative organization (four banks of 64 KB). Set-associative caches offer greater flexibility for storing data items that have similar memory addresses. |

Dedicated Level-Two Cache Bus

The Pentium Pro increases the performance of its level-two cache by accessing it over a dedicated, 64-bit internal bus. This means that accesses to the cache will cause no contention with any operations on the local bus. It also ensures that the level-two cache is able to operate at the full internal clock speed of the processor.



Cache Coherency

One important implication of using cache memories is that duplicate copies of data exist in different parts of your PC. With duplicate copies of the same data, a mechanism must be used to ensure coherency between the copies. This is particularly true for dual processor configurations, where duplications can exist not only between a processor cache and memory, but also between the caches in the two processors.

The Pentium Pro's level-two data cache is a copy-back cache, meaning that if the processor writes data that produces a cache hit, then that data will be written directly in the level-two cache. The cache will then copy the data back to memory at a later time. Until the cache copies the data back to memory, the copy of the data held in memory is no longer valid.

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The Intel Pentium Pro Processor

If another device in your PC requests this data from memory, the Pentium Pro processor must be able to intercept the request so that it can supply the correct version of the data. To meet this requirement, the Pentium Pro processor uses two cache coherency mechanisms: the MESI (Modified, Exclusive, Shared, Invalid) protocol; and bus snooping.

The MESI Protocol

The MESI protocol defines the status of data in the cache using four states:

- Modified — the data is valid, but different to that in memory (the data in memory is invalid)
- Exclusive — the data is valid and contained in one processor cache only
- Shared — the data is valid and copies are stored in the caches of different processors
- Invalid — the data is not valid.

Data is stored in cache memories as cache lines of 32-bytes. Associated with each cache line are two status bits which define the MESI state of the cache line.

Bus Snooping

The Pentium Pro processor monitors accesses to memory by other PC devices (including a second processor, if installed) through bus snooping. This involves intercepting the memory addresses issued by other devices and comparing them with the contents of its cache memories.

If bus snooping produces a cache hit, the action taken by the processor will depend on the MESI status of the cache line that produced the hit: for modified cache lines the processor will intervene to update the copy held in main memory; for shared or exclusive cache lines, the processor will need to modify the MESI state of the cache line.

Higher Clock Speeds

The Pentium Pro processor operates at higher internal clock frequencies than any previous x86 family processor. Typically, the Pentium Pro uses an internal clock that is up to three times faster than the clock used for the local bus.

This increase in clock speeds has been made possible by superpipeline architecture and the additional functions that the Pentium Pro integrates. With a 256 KB level-two cache memory, the Pentium Pro is able to perform much of its work internally, without needing to access its local bus.

The Pentium Pro Local Bus

The new features implemented by the Pentium Pro processor are not limited to its internal operation; the Pentium Pro also uses a new protocol for memory accesses performed over its local bus.

Previous generation processors in the x86 family used a simple protocol for memory accesses on the local bus; once a bus cycle had been initiated it had to be completed before another access could be begun. As memory accesses require a number of clock cycles to complete, this meant that the local bus would be stalled until the access was complete.

Transactional Bus

The Pentium Pro supports a transactional local bus, which allows up to eight memory accesses to be outstanding at any one time. Once a memory access has been issued on the local bus, the Pentium Pro can issue other memory accesses while waiting for the first access to complete. By using this transactional protocol, the Pentium Pro processor is able to make better use of its local bus.

To use the transactional protocol, the Pentium Pro processor requires support from other devices on the local bus, such as the memory controller. If this support is not available, the Pentium Pro will use the simple protocol, used by previous generation x86 family processors, for memory accesses.

Main Memory

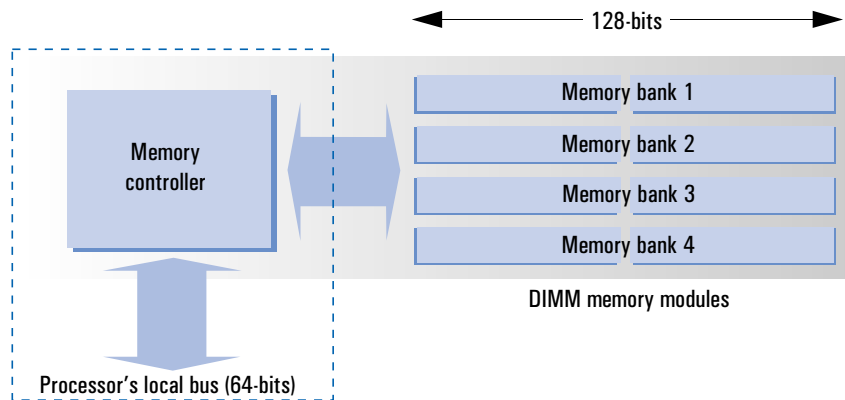
The main memory in your PC consists of Double Interline Memory Modules (DIMMs). 32 MB or 64 MB are fitted as standard (depending on the model you ordered). The main memory can be upgraded to a maximum of 512 MB. Memory modules are available in three capacities: 16 MB, 32 MB and 64 MB. The maximum memory capacity (512 MB) is obtained by installing eight 64 MB DIMM modules.

NOTE

The DIMM modules used by your HP Vectra XU PC use a 5 volt power source. DIMM modules that use a 3.3 volt power source are not supported and must not be installed.

128-bit Memory

Each DIMM module stores 64 bits of data plus 8-bits of Error Correcting Code (ECC) code. Access to the memory modules is controlled by a memory controller on the processor's local bus. This controller manages the modules in pairs to create single, 128-bit wide logical banks.



The processor's local data bus is 64 bits wide. All data written to or read from the memory is transferred on this bus. The memory modules are accessed by the memory controller through two, parallel 64-bit data paths. The memory controller connects these two 64-bit data paths with the processor's bus by interleaving the accesses. This means that consecutive 64-bit accesses to a memory bank are made to different modules.

By using interleaving to access the memory banks, the memory controller actually increases the speed of your PC's memory. This is because of the characteristics of the memory components used.

Main memory uses a type of memory component called Dynamic Random Access Memory (DRAM). DRAM stores data in a rectangular array, so that each data item corresponds to an address (location) which is formed of two parts. These two parts must be sent to the DRAM in separate clock cycles, which means that the data cannot be read from or written to the DRAM in the same clock cycle as the memory controller begins to access it.

With interleaved accesses, the memory controller begins to access the both modules in the pair simultaneously. The time required to access both memory modules is thus less than twice the time required to access a single module. The maximum (peak) data transfer rate that your PC's memory can provide is 267 MB/s.

Another advantage of interleaving is that it enables the memory controller to synchronize its activity with accesses made by the processor. The Pentium Pro processor frequently uses burst transfers to read or write entire cache lines in memory. Cache lines are 32 bytes long, which corresponds to four consecutive data transfers of 64 bits each.

2 Technical Reference

Main Memory

Data Integrity

Previous generations of PCs protected the integrity of memory data by using parity bits stored with each data byte. Parity is calculated by adding up all the data bits in a byte. If the total is an even number, the parity bit is set to 0, while if the total is an odd number this will be 1.

Parity was generated by the PC's memory controller when writing data to memory and this parity would be checked when subsequently reading that data. Any difference between the parity written and that read indicates that one of the bits in the corresponding data byte has changed.

The advantage of parity is that it enables the memory controller to detect if memory data has been changed. However, it does not enable the memory controller to correct the error because the precise bit is not identified. Furthermore, if two bits of data are changed within the same byte of data, no error would be detected.

ECC Code

Your PC uses a different system to guarantee the integrity of your memory data. This system, called Error Correcting Code (ECC), enables the memory controller to detect and automatically correct any single-bit data error that occurs.

ECC Code is generated using a mechanism called 8-bit hamming code. This takes larger, disjointed groups of data bits and performs the same addition used for parity to produce an ECC bit. With eight bytes of data, eight ECC bits will be generated, which means that the groups of bits used to generate the ECC bits overlap.

The groups of data bits used to calculate the ECC bits are carefully selected, so that a change in any one data bit will change a unique combination of the ECC bits. If a single bit data error occurs, your PC's memory controller decodes the ECC bits to identify exactly which data bit has been changed.

Memory Upgrade Path

The memory configuration of your HP Vectra XU PC is very flexible. Your PC's memory capacity can be increased by installing pairs of memory modules of 16 MB, 32 MB or 64 MB in any memory bank in any order. The total memory capacities available are indicated in the following tables (duplicate configurations are ignored).

| Base memory configuration (bank 1) | Memory added to bank 2 | Memory added to bank 3 | Memory added to bank 4 | Total Memory Capacity |
|------------------------------------|------------------------|------------------------|------------------------|-----------------------|
| 32 MB | — | — | — | 32 MB |
| | 32 MB | 32 MB | — | 64 MB |
| | | | — | 96 MB |
| | | | 32 MB | 128 MB |
| | | | 64 MB | 160 MB |
| | | 128 MB | 224 MB | |
| | | 64 MB | — | 128 MB |
| | | | 64 MB | 192 MB |
| | | | 128 MB | 256 MB |
| | | 128 MB | — | 192 MB |
| | | | 128 MB | 320 MB |
| | 64 MB | 64 MB | — | 96 MB |
| | | | — | 160 MB |
| | | | 64 MB | 224 MB |
| | | 128 MB | 288 MB | |
| | | 128 MB | — | 224 MB |
| | | | 128 MB | 352 MB |
| | 128 MB | 128 MB | — | 160 MB |
| | | | — | 288 MB |
| | | 128 MB | 416 MB | |

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Main Memory

| Base memory configuration (bank 1) | Memory added to bank 2 | Memory added to bank 3 | Memory added to bank 4 | Total Memory Capacity |
|------------------------------------|------------------------|------------------------|------------------------|-----------------------|
| 64 MB | — | — | — | 64 MB |
| | 64 MB | 64 MB | — | 128 MB |
| | | | — | 192 MB |
| | | | 64 MB | 256 MB |
| | | 128 MB | 320 MB | |
| | | 128 MB | — | 256 MB |
| | | | 128 MB | 384 MB |
| | 128 MB | 128 MB | — | 160 MB |
| | | | — | 288 MB |
| | | 128 MB | — | 448 MB |
| 128 MB | — | — | — | 128 MB |
| | 128 MB | — | — | 256 MB |
| | | — | — | 384 MB |
| | | 128 MB | — | 512 MB |

All memory banks are 128-bits wide and provide interleaved access, irrespective of their capacity or of the capacity of other memory banks.

Technical Characteristics

The technical characteristics of the HP Vectra XU PC are summarized in the following tables.

| Processors | |
|------------------------|---|
| Type | Intel Pentium Pro |
| Clock speeds | 150 MHz, 180 MHz, 200 MHz |
| Architecture | Three-way, superscaler 64-bit data, 36-bit address Five execution units Out-of-order and speculative execution Advanced dynamic branch prediction |
| Level-one cache memory | 8 KB data, two-way set-associative 8 KB instruction, two-way set-associative |
| Level-two cache memory | 256 KB unified data and instruction, four-way set-associative |
| Local Bus | Transactional 60 MHz or 66 MHz clock |
| Dual processor support | MPS-compliant MESI cache coherency and bus snooping Embedded Advanced Programmable Interrupt Controller (APIC) |
| Memory | |
| Type | 64-bit DIMMs (Double Interline Memory Modules), 5 V only |
| Data integrity | Error Correcting Code (8-bit hamming code) |
| Available capacities | From 32 MB to 512 MB in increments of 32 MB, 64 MB or 128 MB |
| Memory Controller | Controls four 128-bit interleaved memory banks (2 DIMMs each) Capable of detecting and correcting all single-bit data errors |
| Memory Performance | Up to 267 MB per second |

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Technical Characteristics

| PCI Bus | |
|-----------------------|---|
| Clock speed | 33 MHz or 30 MHz, depending on processor clock speed |
| Bandwidth | 132 MB/s or 120 MB/s, depending on processor clock speed |
| Accessory board slots | Four, full-length 32-bit slots (one slot is combination ISA/PCI) |
| Supply | 3.3 volt or 5 volt |
| Connected devices | Integrated SCSI controller Integrated IDE controller Millennium Video Adapter (accessory board) HP 10/100VG LAN interface (accessory board) |
| ISA Bus | |
| Clock speed | 8.75 MHz or 7.5 MHz, depending on processor clock speed |
| Bandwidth | Up to 8 MB/s |
| Accessory board slots | Three, full-length 16-bit slots (one slot is combination ISA/PCI) |
| Connected devices | Integrated keyboard/mouse controller Integrated flexible disk drive controller Integrated parallel/serial port controller Integrated audio subsystem BIOS ROM |
| SCSI Channel | |
| Description | Single 8-bit with internal and external connections |
| Connectivity | Up to seven SCSI peripheral devices (up to five internal) |
| Data transfer rate | Up to 20 MB/s (Ultra SCSI) |
| IDE Channels | |
| Description | Two fast IDE channels supporting split-mode timings |
| Connectivity | Up to four IDE mass storage devices (two per channel) |
| Data transfer rate | Up to 16,7 MB/s (PIO mode 4 or DMA Mode 2) |

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Technical Characteristics

| Video Controller | |
|-------------------------|---|
| Description | 64-bit MGA Millennium Video Adapter installed on PCI bus |
| Video memory | 2 MB WRAM, upgradeable to 4 MB or 8 MB |
| Supported resolutions | 640 × 480 800 × 600 1024 × 768 1152 × 882 1280 × 1024 1600 × 1200 |
| Displayable colors | 16.7 million (true-color) |
| Refresh rates | Up to 200 Hz |
| Audio Subsystem | |
| Description | Integrated SoundBlaster™ 16 compliant |
| Stereo sampling | 16-bit and 8-bit at frequencies from 5 KHz to 44.1 KHz |
| Music Synthesizer | FM-OPL3 synthesis using four operators on 20 polyphonic voices |
| Mixer | Multiple source recording Left/right channel swapping or mixing 8-level volume control (4-level for PC speaker) Inputs: FM music synthesizer, microphone, line in, CD audio and PC speaker |
| Stereo amplifier output | Two watts per channel into 4 ohm impedance |
| MIDI interface | SoundBlaster and MPU-401 mode compatible MIDI time-stamp for multimedia extension 64-byte FIFO input buffer |

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Technical Characteristics

| HP 10/100BT LAN Interface | |
|----------------------------------|--|
| Description | HP DeskDirect 10/100TX adapter installed on PCI bus |
| Protocol | 100BASE-TX Fast Ethernet standard |
| Data transfer rates | 10 Mbit/s (IEEE 802.3) 100 Mbit/s (IEEE 802.3u) |
| HP 10/100VG LAN Interface | |
| Description | 10Base-T/100VG AnyLAN interface installed on PCI bus |
| Protocol | Demand Priority Access |
| Data transfer rates | 10 Mbit/s (IEEE 802.3) 100 Mbit/s (IEEE 802.12) |

| Memory Address Map | |
|---|---|
| Address | Description |
| 0 - 3FFh (0 to 1KB) | Interrupt Vector Table |
| 400h - 4FFh (1 KB to 1 KB + 256 bytes) | BIOS Data Area |
| 500h - 9FFFFh (1 KB + 256 bytes to 640 KB) | Base Memory Used by PC operating systems and software applications |
| A0000h - BFFFFh (640 KB to 768 KB) | Video Memory |
| C0000h - C7FFFh (768 KB to 800 KB) | Video BIOS Data Area |
| C8000h - DFFFFh (800 KB to 896 KB) | Available for accessory board BIOS |
| E0000h - EFFFFh (896 KB to 960 KB) | Available Used by PC operating systems for device drivers |
| F0000h - FFFFFh (960 KB to 1024 KB) | BIOS Area |
| 100000h - F00000h (1024 KB to top of memory) | Extended Memory Used by software applications |
| DMA Channels | |
| DMA 0 | Available |
| DMA 1 | Available if not used by parallel port or audio subsystem |
| DMA 2 | Flexible disk drive controller |
| DMA 3 | Available if not used by audio subsystem |
| DMA 4 | Used to cascade DMA channels 0-3 |
| DMA 5 | Available if not used by audio subsystem |
| DMA 6 | Available |
| DMA 7 | Available if not used by audio subsystem |

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Technical Characteristics

| I/O Address Map | |
|--|---|
| Address (hexadecimal) | Function |
| 170h - 177h | Integrated IDE controller (secondary channel) |
| 1F0h - 1F7h | Integrated IDE controller (primary channel) |
| 220h - 22Fh | SoundBlaster™ 16 audio subsystem (can be relocated) |
| 278h - 27Fh | Parallel port 2 |
| 2E8h - 2EFh | Serial port 4 |
| 2F8h - 2FFh | Serial port 2 |
| 300h - 301h | MPU-401 MIDI interface (can be relocated) |
| 330h - 331h | MPU-401 MIDI interface (can be relocated) |
| 376h | Integrated IDE controller (secondary channel) |
| 377h | Integrated flexible disk controller |
| 378h - 37Fh | Parallel port 1 |
| 388h - 38Bh | Music controller (can be relocated) |
| 3E8h - 3EFh | Serial port 3 |
| 3F0h - 3F5h | Integrated flexible disk controller |
| 3F6h | Integrated IDE controller (primary channel) |
| 3F7h | Integrated flexible disk controller |
| 3F8h - 3FFh | Serial port 1 |
| Interrupt Request Levels (IRQs) | |
| IRQ 0 | System timer |
| IRQ 1 | Keyboard controller |
| IRQ 2 | Used to cascade IRQs 8-15 |
| IRQ 3 | Available if not used by serial port |
| IRQ 4 | Available if not used by serial port |
| IRQ 5 | Available if not used by parallel port or audio subsystem |
| IRQ 6 | Flexible disk drive controller |
| IRQ 7 | Available if not used by parallel port or audio subsystem |
| IRQ 8 | Real-time clock |
| IRQ 9 | Available for PCI if not used by an ISA accessory board |
| IRQ 10 | Available for PCI if not used by an ISA accessory board or audio subsystem |
| IRQ 11 | Available for PCI if not used by an ISA accessory board |
| IRQ 12 | Mouse controller if not disabled through the <i>Setup</i> program (if so - available) |
| IRQ 13 | Processor (floating-point unit) |
| IRQ 14 | Integrated IDE controller |
| IRQ 15 | Available if not used by integrated IDE controller |

